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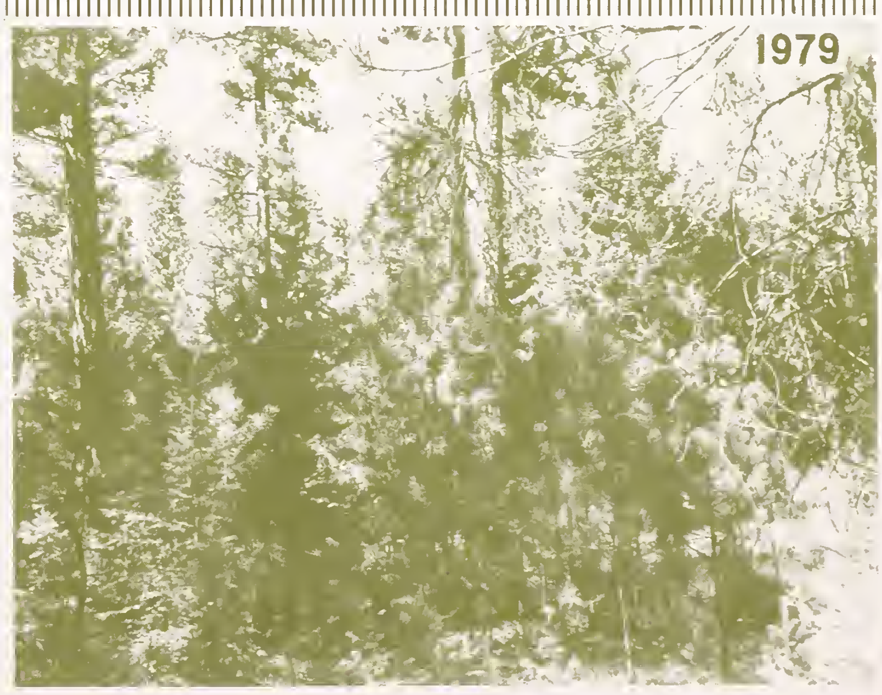
# Seventy Years of Vegetative Change in a Managed Ponderosa Pine Forest in Western Montana—Implications for Resource Management

**George E. Gruell, Wyman C. Schmidt,
Stephen F. Arno, and William J. Reich**



# THE AUTHORS

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# CONTENTS





# RESEARCH SUMMARY

This paper documents successional changes in a ponderosa pine forest in the Bitterroot Valley of western Montana. The area described comprises the Lick Creek timber sale of 1906, the first large ponderosa pine sale in the USDA Forest Service Northern Region. The timber volumes, cutting methods, volume removed, and subsequent management are discussed. Prior to cutting, frequent low-intensity surface fires were a major influence on the vegetation of Lick Creek. Consequently, fire history is treated in some detail.

A series of 11 photopoints, photographed at about 10-year intervals starting in 1909, provide a basis for interpretations. The photographs show dramatic changes in vegetation as a result of disturbance from timber harvest and virtual exclusion of wildfire. The forest structure was originally dominated by mature ponderosa pine with an open understory. This structure was converted to widely spaced mature pines interspersed within dense second-growth mixed ponderosa pine/Douglas-fir forests. Subsequent reentries opened these stands and allowed increased establishment and growth of conifers and shrubs. Implications for management resulting from forestry practices are as follows:

1. Repeated timber harvests at Lick Creek have demonstrated that it is possible to partially cut old-growth ponderosa pine-dominated stands and obtain ample regeneration. Growth release on residual mature trees has been modest, but release in thinned second-growth stands has been substantial.
2. The cutting program coupled with fire suppression over the past 70 years has favored regeneration of Douglas-fir over ponderosa pine on much of the area. A dense understory of trees developed in response to partial cuttings.
3. The increase in understory tree cover and shrubs has changed wildlife habitat. Species that require dense cover, such as white-tailed deer and snowshoe hare, have been favored. Species that require minimal cover, like ground squirrels and pocket gophers, would not be favored.
4. Present conifer stands are more susceptible to crown fires than the early stands because of the increase in ladder fuels. Down and dead fuels have continued to be light except for slash created by precommercial thinning.
5. In the decades following initial logging, scenic quality has deteriorated because dense conifer regeneration has obstructed views.
6. After about 1912, livestock grazing on the Lick Creek sale area apparently has been light and therefore has influenced vegetative development very little.



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## INTRODUCTION

More than 100 years have passed since the initial settlement of western Montana. During this period forest vegetation has changed, but there is little documentation on the degree of changes, what brought about these changes, and the effect of these changes on forest resources and activities. This paper contains a photographic record and supporting evidence of successional changes in a ponderosa pine/Douglas-fir forest typical of western Montana. This area and comparable lands were logged (mostly partial cuts) starting as early as the 1880's. Logging, grazing, and fire suppression resulted in successional changes that differed from those that occurred in the presettlement environment. The implications of forest succession on timber management, wildlife habitat, livestock grazing, forest fuels, and scenic quality are discussed. Content should prove useful to silviculturists, foresters, fire management officers, wildlife biologists, and others who have management responsibilities. This information should also be useful in furthering ecologically sound forest management.

## THE SETTING AND HISTORICAL BACKGROUND

For much of forested North America, there is little reliable information on changes in vegetation over long periods of time. An exception is the Lick Creek drainage on the Bitterroot National Forest in Montana, thanks to the foresight of USDA Forest Service personnel who have photographically recorded vegetation over the past 70 years. This photographic series provides a unique opportunity to visually interpret changes in a ponderosa pine/Douglas-fir forest (see appendix for common and scientific names of trees and undergrowth). Changes depicted also allow an evaluation of how resource uses and activities have been influenced by logging and exclusion of wildfire. Similar changes have occurred over much of the ponderosa pine/Douglas-fir type in western Montana, where shade-tolerant Douglas-fir represents the potential climax were it not for disturbances like fire and logging.

The photo study is located on Lick Creek (lat. 46°5' N., long. 114°15' W.), site of a 1906 ponderosa pine timber sale on National Forest lands. This area is 13 airline miles (21 km) southwest of Hamilton, Mont., at elevations between 4,300 and 4,600 ft (1 311 and 1 402 m) (fig. 1). The terrain in this locality is mostly 10 to 30 percent slopes except for localized northerly and southerly slopes of up to 70 percent. Soils are derived from granitic parent materials and are shallow to moderately deep. Some poorly drained areas and clay soils exist at the lowest elevations.

Weather data recorded between 1941 and 1970 at Darby (elev. 3,887 ft [1 185 m]), Mont., 5 airline miles (8 km) southeast of the study area, suggest that the mean annual precipitation at Lick Creek is between 20 and 22 inches (51 and 56 cm) (USDA Soil Conservation Service 1977). Approximately 50 percent of this falls in the form of snow.

Because many years have passed since the original timber sale, records concerning USDA Forest Service participants are sketchy. Some of the people who are known to have been involved included Bitterroot Forest Supervisor, W. W. White, who administered the sale; John Preston, acting deputy forest supervisor; Earl Tanner; E. C. Clifford; Claget Sanders, the scaler; and "lumberman" C. J. Gregory. Although no documentation has been found, there is evidence that Gifford Pinchot, the first Chief of the USDA Forest Service, provided direction for this sale (personal communication, Arthur Roe, Forest

# VICINITY MAP

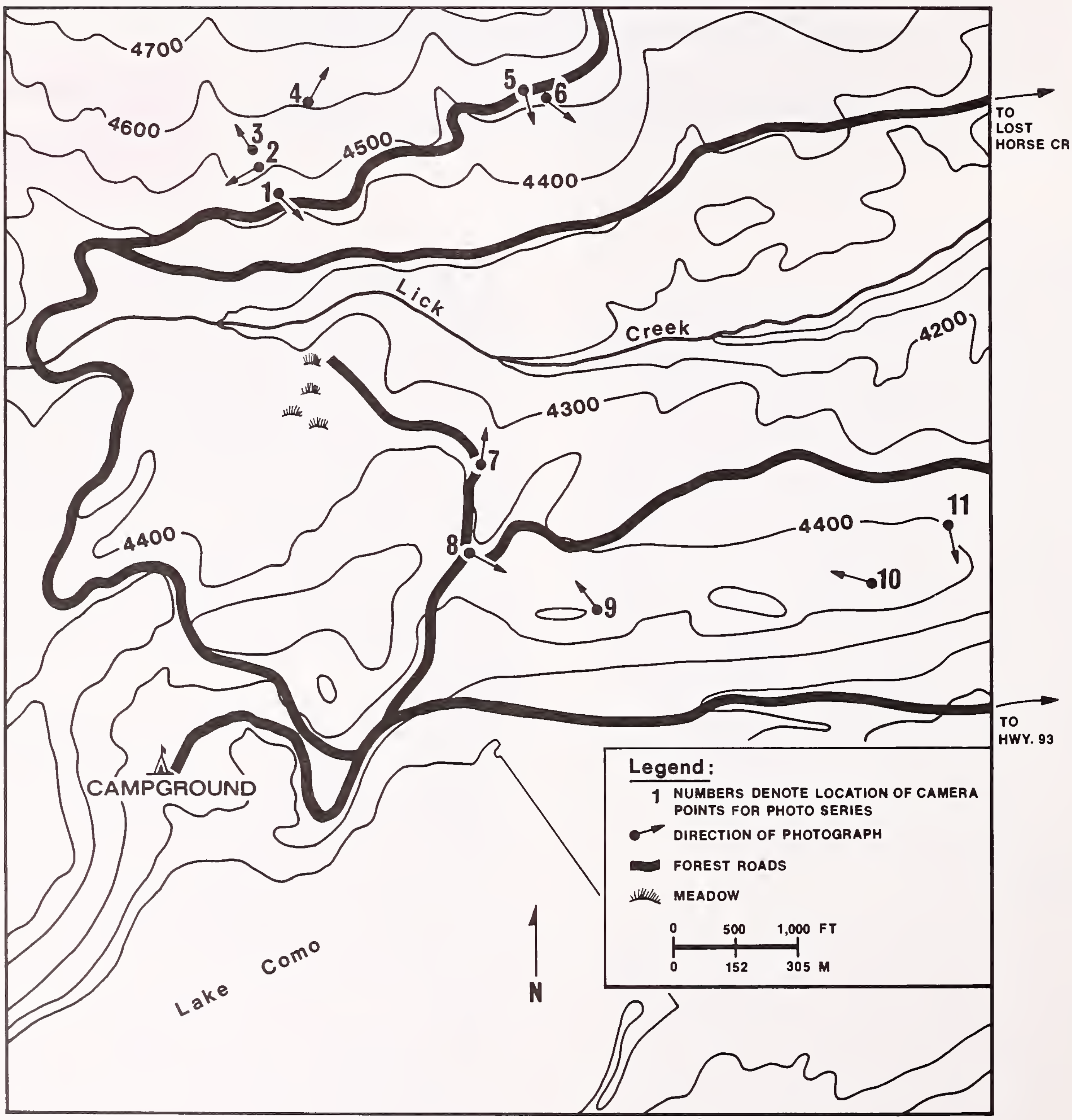




*Figure 1.—Lick Creek study area.*

Service retired, and Charles Wellner, Forest Service retired). The Big Blackfoot Milling Company, a subsidiary of the Anaconda Copper Mining Company, purchased the timber and did the logging according to USDA Forest Service specifications.

Because of the importance of the Lick Creek sale, in 1909 a Washington Office photographer, W. J. Lubkin, was sent West to document the logging activity. Lubkin obtained excellent photos by using a 6½- by 8½-inch (17-by 22-cm) view box camera and glass plates.

The camera points were not permanently marked because this was not part of the assignment. Fortunately, in November 1925, K. D. Swan, photographer for the USDA Forest Service Northern Region, accompanied W. W. White on a trip to the Lick Creek area to see if the camera points could be located. Swan (1968) recalled how White was able to locate the original photo points:

> The quest was extremely fascinating. White had a good memory and was able to spot, in a general way, the locations we were after. Peculiar stumps and logs were a great help. Just when we might seem baffled in the search for a particular spot, something would show up to give us a key. The clue might be the bark pattern on a ponderosa pine, or perhaps a forked trunk.
>
> The camera we were using duplicated the one used for the original pictures, and when a spot was once found it was a simple matter to adjust the outfit so that the image on the ground glass would coincide with the print we were holding. It was an exciting game, and we felt it was more fun than work.

In 1938, the temporary camera points located in 1925 were permanently marked with brass caps by Forest Supervisor G. M. Brandborg and Ranger C. Shockley. The original photographs were repeated in 1925, 1927, and 1937 by K. D. Swan. He was followed by three other USDA Forest Service employees: W. E. Steuerwald, 1949, 1958; Wyman Schmidt, 1969; and William Reich, 1979. Most of the retake photographs were made with 4- by 5-inch (10- by 13-cm) Crown Graphic cameras.

## SILVICULTURAL STORY

The Lick Creek timber sale of 1906 attracted much attention because it was the first large national forest timber sale (2,135 acres [864 ha]) in the ponderosa pine type in the USDA Forest Service Northern Region. A total of 37,600,000 bd.ft. was cut.

Professional forestry and the USDA Forest Service were in their infancy in the United States at that time, and there was little research or experience on which to base silvicultural prescriptions in any of our forest types. Ponderosa pine was, and continues to be, a high-value timber species.

Frequent light ground fires had favored ponderosa pine and had suppressed its more shade-tolerant associate in this type—Douglas-fir. Douglas-fir was economically less desirable than ponderosa pine, so silvicultural practices were aimed at perpetuating pine and reducing the fir component. Autecological requirements of all species were just beginning to be understood. Therefore silvicultural treatments were based on limited knowledge.

### Harvest Cutting Treatments, 1907-11

The virgin stand was composed chiefly of mature and overmature ponderosa pine. Douglas-fir of inferior quality comprised about 10 percent of the stand volume. A small amount of grand fir and spruce was included in the Douglas-fir volume. Total volume of sawtimber (10 inches [25.4 cm] d.b.h. and larger) of all species averaged 20,810 bd.ft. per acre. Timber age ranged from 200 to 400 years, and based on Meyer's yield tables (1938), the site was originally classified as IV and V (about 39 to 50 ft [12 to 15 m] tall at 50 years). Subsequent evaluations indicate that these sites are actually more productive than that, with potential site indexes for uncrowded trees averaging about 52 to 55 ft (16 to 17 m) tall at 50 years for ponderosa pine and Douglas-fir (Pfister and others 1977; personal communication, B. John Losensky, USDA Forest Service Northern Region, Missoula, Mont.).

Although original descriptions of the Lick Creek cuttings did not classify the silvicultural system, it can best be described as a selective cutting. Timber marking practices in this early cutting followed these criteria:

1. Leave reserve timber for a second cut after 75 years.
2. As a general guide, reserve about 30 percent of the volume.
3. Cut Douglas-fir heavily (generally inferior quality).

Actual marking practices varied considerably during the 1907-11 period. A limited area was cut to a 19-inch (48-cm) diameter limit (everything over 19 inches [48 cm] was cut). The original stand contained an average of about 50 trees per acre (124/ha). Of these, an average of 25 per acre (62/ha) were cut in the 1907-11 period. Because most of the trees harvested were the larger trees, basal area remaining after logging averaged only about 37 percent of the original 121 ft$^2$ per acre (27 m$^2$/ha). Size class distribution of the residual stand after cutting was:

| Size Class | | Number Trees Per | |
|---|---|---|---|
| *Inches* | *cm* | *Acre* | *Hectare* |
| 6 to 8 | 15 to 20 | 2 | 5 |
| 10 to 12 | 25 to 30 | 6 | 15 |
| 14 to 16 | 36 to 41 | 6 | 15 |
| 18 to 20 | 46 to 51 | 5 | 12 |
| 22 to 24 | 56 to 61 | 3 | 7 |
| 26 to 30 | 66 to 76 | 2 | 5 |
| 32 + | 81 + | 1 | 2 |

Residual basal areas and volumes, however, varied greatly on the cutover area, ranging from about 5 to 50 percent of the original stand (Boe 1948).

Actual cutting took place during the 1907-11 period, covering 2,135 acres (864 ha), 1,916 acres (776 ha) of which were classified as pine type, and 219 acres (88 ha) of which were classified as Douglas-fir and spruce. Grand fir was included in the latter. (Most of the area and all of the photopoints are within Douglas-fir habitat types [Pfister and others 1977].) A grand fir habitat type including some spruce occurs in moist sites along Lick Creek.

## RESIDUAL STAND GROWTH RESPONSE

An evaluation of the Lick Creek area 35 years after the 1907-11 cuttings showed that average stand volume of trees 10 inches (25 cm) d.b.h. and larger had increased from 3,810 bd.ft. per acre (9 411/ha) in the residual stand in 1911 to 6,127 per acre (15 134/ha) in 1946 (Roe 1947a). This amounted to 66 bd.ft. per acre (163/ha) annual net growth. Fortunately, the residual stands that made up this average varied substantially and provided a basis to evaluate the effect of residual volume capital on subsequent growth.

To make these evaluations, Roe (1947a) grouped the 1911 residual volumes into four broad classes averaging 627 residual bd.ft. per acre (1 549/ha), 2,396 per acre (5 918/ha), 4,655 per acre (11 498/ha), and 9,089 per acre (22 450/ha).

Largest net volume increments were made in the heaviest residual stands. As shown in figure 2, average annual increment ranged from 2 bd.ft. per acre (4.9/ha) where the reserve stand had averaged 627 bd.ft. per acre (1 549/ha), to 126 bd.ft. per acre (311/ha) where the reserve stand had averaged 9,028 bd.ft. per acre (22 299/ha). Most growth was made by merchantable-size trees reserved at the time of the initial logging.

Although the greatest per acre gains were in stands with heaviest residual volumes, on a percentage basis, the most significant increases were in stands averaging 4,655 bd.ft. per acre (11 498/ha) (fig. 3) (Roe 1947b).

In the stands with light residual volume, Douglas-fir contributed most to the ingrowth (trees less than 10 inches [25 cm] d.b.h. at the time of the initial harvest that exceeded 10 inches [25 cm] d.b.h. at the 35-year measurement). The opposite was true in the stands with heavy residuals after the initial cutting. Here, nearly all of the 35-year growth was in ponderosa pine 10 inches (25 cm) d.b.h. and larger at the time of the initial cutting. Intermediate reserve stand volumes resulted in intermediate response values in relation to both species composition and volume growth. Thus, stand volume capital played a role in evaluating the efficacy of reserving different levels of stand volume.

White (1924)[1] described effects of release on individual ponderosa pine trees. He concluded that: "It was noticed that the removal of one or more trees on the north seemed to have as much effect on increased growth as where the removal was on the south. This was so pronounced that the conclusion is reached that root competition in yellow pine stands is fully as important a factor as light."

Volume increment in stands with the heaviest residual volume increased rapidly, peaked the second 5-year period after logging, remained relatively high for about 20 years, and then gradually declined (Roe 1947b). In stands with lighter residual volumes, the same trends were observed, except that ingrowth and apparent increased precipitation in the 30- to 35-year period after logging, resulted in increased growth.

[1]White, W. W. Study of Lick Creek timber sale area 15 years after cutting. Hamilton, MT: U.S. Department of Agriculture, Forest Service, Bitterroot National Forest; April 28, 1924. 16 p. Office report.

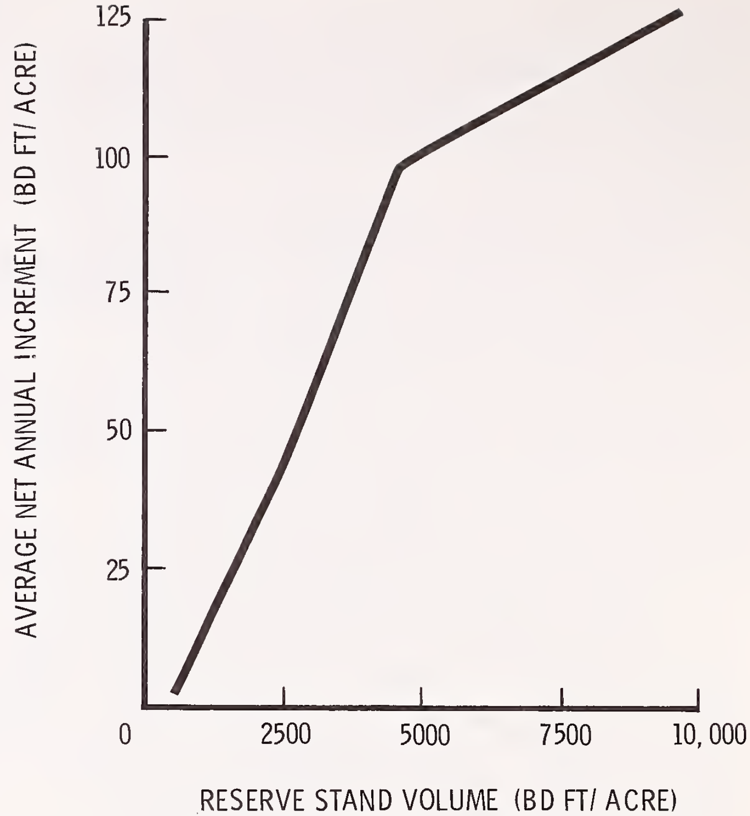



*Figure 2.—Average annual net volume increment for 35 years following harvest cutting in relation to reserve stand volume.*

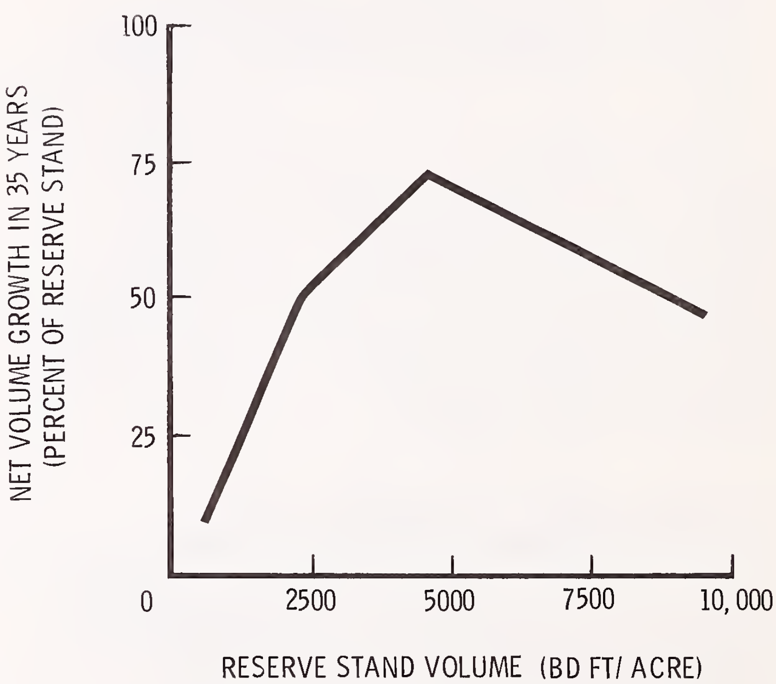



*Figure 3.—Thirty-five year net volume growth as a percent of the reserve stand.*

Ingrowth played a relatively small part over all of the cutover area because there were few understory trees, seedlings, saplings, and poles in 1907. Frequent ground fires precluded survival of most understory trees before that time.

The reserve stand was apparently chosen with a good appreciation of tree vigor. Mortality averaged only 8 to 18 bd.ft. per acre (20 to 44/ha) annually for the 35-year period. No relationship of mortality rates to residual stand volume was detected. White (1924),[1] concluded that most

mortality was due to windfall shortly after the cuttings, but a small amount was due to bark beetles. Ninety percent of the wind losses occurred the first 3 years after cutting. Windfall was worst on the east and southeast sides of large openings created by the logging. West and northwest winds were responsible for the wind losses.

### NATURAL REGENERATION RESPONSE TO INITIAL TREATMENTS

During the 1907-11 harvest, logs were transported to landings by means of log chutes, horse skidding, and steam donkey yarding. Slash was disposed of by piling and burning. Usually this type of logging and postlogging treatment results in relatively light site disturbance, and the photo series tends to corroborate this. Some advance natural regeneration, primarily Douglas-fir, was present in the stand prior to logging; most of it became established in the 10-year period prior to logging (Boe 1948). However, opening of the stand, site disturbance of the logging, and apparent good seed crops resulted in adequate subsequent regeneration. White (1924)[1] stated: "Along about 1912, there was a heavy yellow pine seed crop. That fall, in October, the area was grazed close by sheep." The most successful regeneration period was the first 10 years after logging, with a gradual decline in the second and third decades.

Total subsequent regeneration combining all species was best where reserve volumes averaged about 2,500 bd.ft. per acre (6 175/ha). Lighter volumes resulted in lesser amounts of regeneration. Reserve volumes greater than 2,500 bd.ft. contributed little or no additional aid in seedling establishment except on southerly aspects where it enhanced Douglas-fir establishment. Apparently, reserve volumes of about 2,500 bd.ft. provided reasonably good conditions for all species, with an adequate seed source, and shade and moderate competition during the establishment period.

Some conclusions that came out of the evaluations of natural regeneration were (Boe 1948):

1. Douglas-fir reproduction tends to become established in advance of cutting, due to greater shade tolerance. The tendency is more pronounced on the cooler, moister north aspects where Douglas-fir predominates. Ponderosa pine generally regenerates after logging and predominates on the south slopes.
2. It took about 20 years after cutting to restock the area; however, the peak establishment occurred in the first 10 years.
3. Height growth of young ponderosa pine and Douglas-fir was about equal for the first 40 years, each averaging slightly more than 0.6 ft (19 cm) annually. Consequently, if both species become established at the same time, the danger of Douglas-fir crowding out the pine is greatly decreased.

## Harvest Cutting Treatments, 1952-Present

Growth evaluations 35 years after the initial cuttings indicated that a second cutting was needed to better capitalize on growth potential of the site. So in the fifties, additional cuttings were made on a limited portion of the original cutover area. The following cutting methods were imposed on 468 acres (189 ha) within the original 1907-11 cutover area:

**Method A**

Remove old stand in four cuttings; the first in 1907-11, and the other three at 10-year intervals starting in 1952.

**Method B**

Remove old stand in three cuttings; the first in 1907-11, half the old residual in 1955, and the other half in 1962.

**Method C**

Remove old stand in two cuttings; the first in 1907-11, and the remainder of the residual stand in 1955.

At the time of the second cutting in the fifties, stand volumes averaged about 10,000 bd.ft. per acre (24 700/ha). Method A removed about one-fourth, Method B about one-half, and Method C about two-thirds of the total merchantable volume (10 inches [25 cm] d.b.h. and over) in the 1952 and 1955 cuttings. Logs were mainly tractor skidded, with a pan under the front of the logs; however, there was some supplemental jammer skidding.

Marking practices to accomplish these partial cuttings were:

1. Remove high-risk trees (those which would not survive 10 to 20 years).
2. Cut spike-topped and lightning-damaged trees.
3. Remove poor-quality subordinates of merchantable size, and poor-quality, rough dominants in mature and overmature groups.
4. Release high-quality subordinates by removing rough dominants in young bull pine groups.
5. Harvest extremely slow-growing, overmature trees.
6. Cut all merchantable Douglas-fir (lower merchantable diameter limit was 14 inches [36 cm] d.b.h.).
7. Remove all trees with visible butt rot or those leaning more than 20 degrees.

### RESPONSE TO HARVEST CUTTINGS

Response following the fifties cuttings was similar to that after the original 1907-11 cuttings; greatest increases in merchantable volume were in stands with the largest reserve volumes. Net volume growth following the fifties harvest cuttings exceeded that after the original cuttings, ranging from about 150 bd.ft. per acre (370/ha) annual increment in stands with 2,000 bd.ft. reserve stand per acre (4 940/ha) to 235 bd.ft. (580/ha) in stands with 12,000 bd.ft. (29 640/ha) reserve stand volume. Ingrowth accounted for about 30 percent of the volume growth in the lightly stocked reserve stand and only about 3 percent in the more heavily stocked reserve stand. About half of the ingrowth was Douglas-fir in spite of the attempts to enhance ponderosa pine and discourage Douglas-fir.

Unfortunately, there was no evaluation of total cubic foot volume, which would have provided a better basis for evaluating the different treatments. Also, only one measurement was made 5 years after treatment.

Lumber recovered from these second cuttings was similar in quality to that from virgin stands. Approximately 15 percent of the lumber was select, 60 percent in two and three common grades, and the remainder in lower grades.

## Immature Stand Culture

Culture of immature stands was started in the fifties on the Lick Creek study area. More than 5,000 ponderosa pine crop trees (100 per acre [247/ha]) were released and pruned on the area cut with method A of the 1952 partial cutting. Trees were 4 to 9 inches (10 to 23 cm) d.b.h. at the time. Release was provided by removing competitors in a 3- to 6-ft (1- to 2-m) radius around the crown of each crop tree. To increase quality of the featured ponderosa pine crop trees, each was pruned to at least 17 ft (5 m). Cost of release and pruning at that time was about $0.50 per crop tree, broken down into $0.25 for pruning, $0.16 for release, and $0.09 for supervision, supplies, and transportation costs.

Five-year evaluations of various intensities of pruning ponderosa pine showed a considerable reduction in d.b.h. growth on the severely pruned trees, with proportionately less reduction on the lightly pruned (fig. 4). Height growth was not affected.

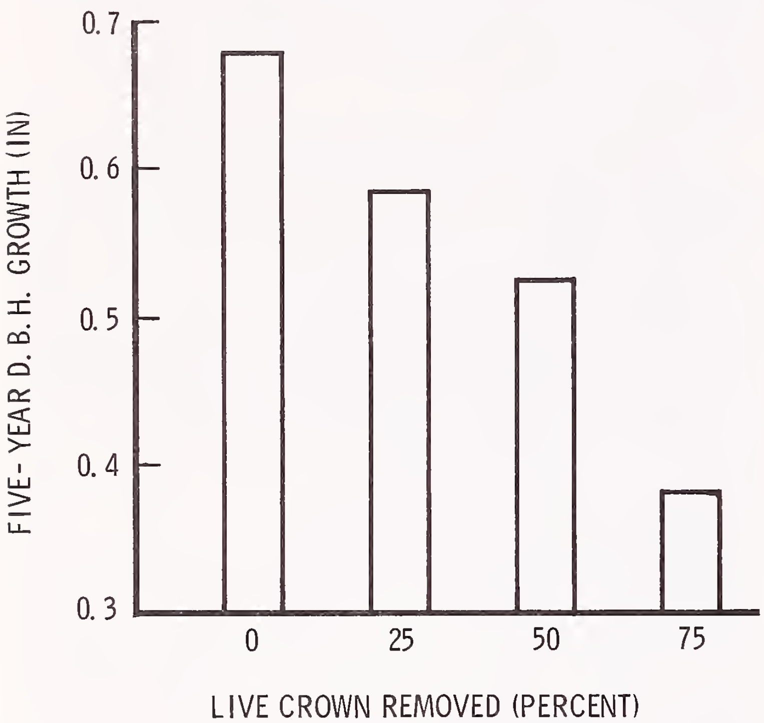



*Figure 4.—Five-year diameter of 4- to 9-inch d.b.h. ponderosa pine crop trees following release as related to amount of crown pruning.*

Cone stimulation studies were also conducted on this area. These studies showed that partial mechanical girdling of young ponderosa pine (50 years) would substantially increase cone production (Shearer and Schmidt 1970). Older trees (140 and 220 years), however, showed little additional cone production as a result of girdling treatments.

## Summary

In summary, a variety of silvicultural practices have been attempted on the Lick Creek area. The long case histories and observational data of partial cutting, release, pruning, and cone stimulation practices provide valuable clues for management of this important forest type.

# NATURAL FOREST SUCCESSION

"Succession" is the term applied to a change or sequence of vegetation on a given site through time. For example, a succession of plant communities that follows clearcutting with broadcast burning of slash might be: (1) grass-forb, (2) shrubfield, (3) saplings and shrubs, (4) pole-size trees, (5) mature forest, and (6) old-growth forest. Succession also applies to the sequence of species that dominate a general community type. Thus, a forest stand may initially be dominated by ponderosa pine (a shade-intolerant tree), which gives way to Douglas-fir (mid-tolerant), and finally to grand fir (shade-tolerant) with increasing time since disturbance. Modern forest managers need to be able to understand and predict succession because vegetation change greatly affects management for grazing, wildlife, timber, watershed, and recreational values.

The Lick Creek photopoints present a rare opportunity to witness forest succession in managed stands through 70 years of time. But in order to assess this management-influenced succession, we should be aware of the kind of forest succession that preceded it. The photopoints occur on two general types of sites or "habitat types," which support somewhat different vegetation and have different patterns of succession (Pfister and others 1977). A habitat type is a measure of site (physical environment) based upon the potential climax vegetation—the type of plant community that represents the self-perpetuating "end-point" of succession.

Fire and other disturbances usually prevent development of climax communities in these forests, but a knowledge of shade tolerances and successional trends allow us to identify the theoretical or potential climax on most sites. This ultimate vegetative type is a reflection of the overall physical environment.

All of the Lick Creek photopoints occur on sites where Douglas-fir (*Pseudotsuga*) is the potential climax dominant tree. The majority of points are located on two relatively dry Douglas-fir habitat types:

1. *Pseudotsuga menziesii/Calamagrostis rubescens* h.t., *Pinus ponderosa* phase (PSME/CARU-PIPO; Douglas-fir/pinegrass h.t., ponderosa pine phase); and
2. *Pseudotsuga menziesii/Symphoricarpos albus* h.t., *Calamagrostis rubescens* phase (PSME/SYAL-CARU; Douglas-fir/snowberry h.t., pinegrass phase).

However, two photopoints are on moist Douglas-fir habitat types:

1. *Pseudotsuga menziesii/Vaccinium globulare* h.t., *Arctostaphylos uva-ursi* phase (PSME/VAGL-ARUV; Douglas-fir/blue huckleberry h.t., kinnikinnick phase); and
2. *Pseudotsuga menziesii/Vaccinium caespitosum* h.t. (PSME/VACA; Douglas-fir/dwarf huckleberry h.t.).

It is evident from the early photographs, accounts of early forest conditions (Leiberg 1899), and fire history studies (Arno 1976), that prior to logging and the advent of fire suppression (about 1910), the lower elevation forests of the Bitterroot Valley were made up of well-stocked stands of large ponderosa pine having open understories. Surface fires swept through these stands at intervals of between 3 and 30 years (Arno 1976), killing most of the tree regeneration, but causing little damage to overstory

trees except for fire scars at the base of the trunk (Leiberg 1899). These fires killed the aerial portions of grasses and shrubs, but afterwards most of these species regenerated from underground organs.

Lightning was a principal cause of these fires, but recent studies (Barrett 1980, 1981) point out that Native Americans (Salish and others) were also an important ignition source. Settlement by European Americans became significant in the Bitterroot Valley below Lick Creek starting about 1860, but apparently this had little effect upon the role of fire until about 1900 (Arno 1976). Fire scar studies from similar sites in the Bitterroot Valley indicate that the pattern of frequent surface fires was in effect at least as early as 1500.

In the spring of 1980, Arno and Gruell spent several hours searching the central portion of the photopoint study area for evidence of fire history. They found that large, old fire-scarred stumps (mostly ponderosa pine, but also some Douglas-fir on north-facing slopes) are common throughout the area. Evidently, most of these are the remains of trees cut in the 1907-11 logging, and many of them were scarred by at least 6 to 12 different fires in the 200 to 250 years prior to logging. We cross-sectioned six of the best preserved and most complete fire-scar sequences, four from pitch stumps of ponderosa pine, and two from the bases of living pines. The cross-sections were sanded and annual rings were counted under magnification in order to date the probable year of each fire scar. These fire-scar dates from the individual stumps and trees were then correlated and adjusted slightly to account for minor ring errors as described by Arno and Sneck (1977). This produced a fire chronology for the stand as a whole. The individual fire scar records and the fire chronology are presented in table 1.

These records indicate that light surface fires swept through the forest at intervals averaging 7 years between A.D. 1600 and 1900. One of the cross-sectioned stumps (labeled "below photopoint 6" in table 1) shows 16 fire scars between 1752 and 1890 (fig. 5).

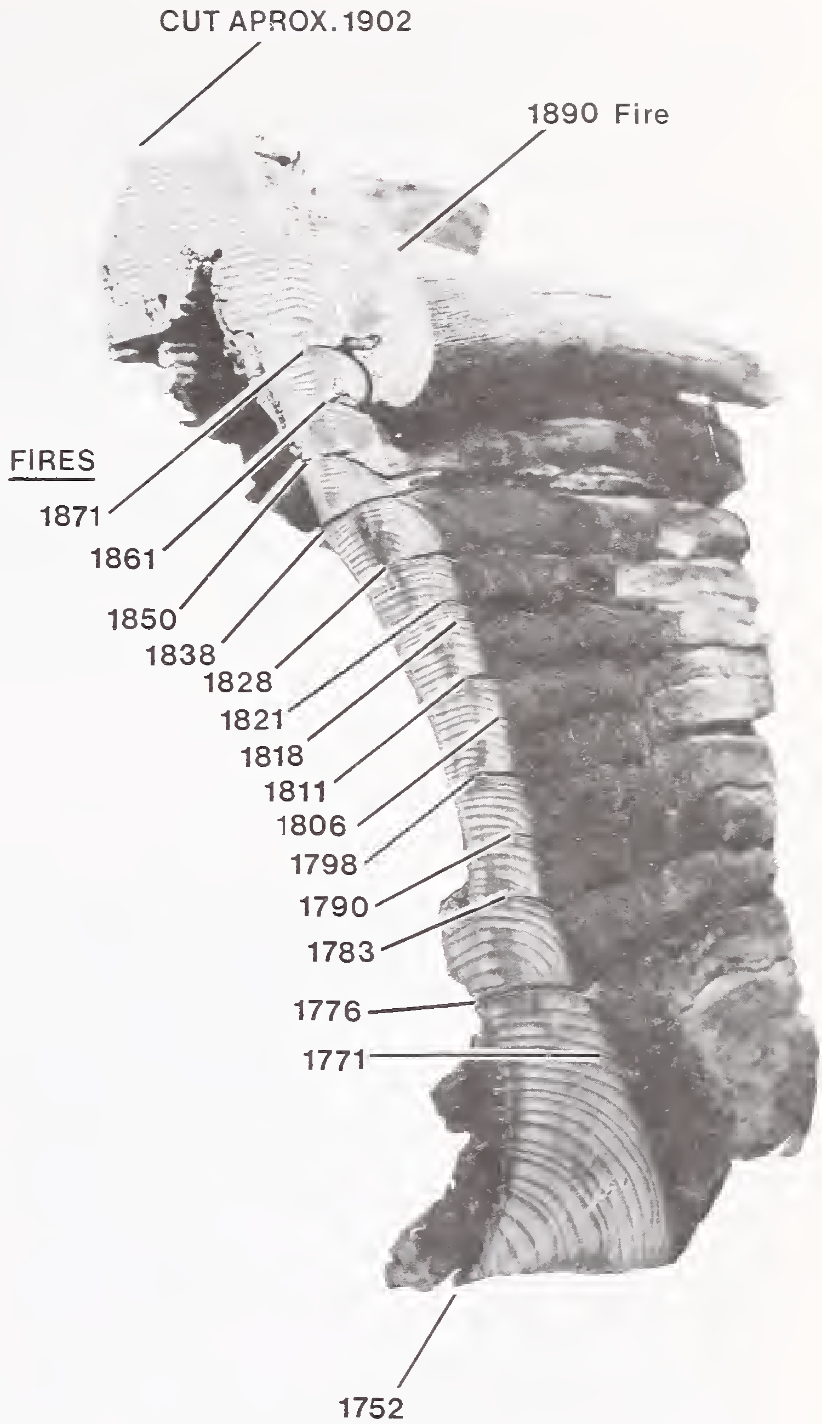



*Figure 5.—Cross-section from the ponderosa pine stump below photopoint 6 (table 1) at Lick Creek, showing 16 fire scars between 1752 and 1890.*

*Table 1.—Fire chronologies for six fire-scarred trees and stumps at the Lick Creek photopoints, Bitterroot National Forest; X = an individual fire scar (42 fires between 1600 and 1900 yields a mean interval of 7 years)*

| Estimated fire year | Live tree at photopoint 3 (cambium 1979) | Stump at photopoint 2 (cut about 1905) | Stump at photopoint 1 (cut after 1903) | Live tree below photopoint 6 (cambium 1979) | Stump below at photopoint 6 (cut about 1902) | Stump at photopoint 8 (cut about 1906) |
|---|---|---|---|---|---|---|
| 1895 | | X | | X | | |
| 1890 | | X | | X | X | |
| 1883 | | | X | | | X |
| 1875 | | X | | | | |
| 1871 | X | X | X | X | X | X |
| 1861 | | | X | X | X | |
| 1856 | | | | X | | X |
| 1850 | | X | | | X | |
| 1846 | | | | | | X |
| 1842 | | | X | | | X |
| 1838 | X | X | | X | X | X |
| 1832 | | | | | | X |
| 1828 | X | | | | X | |
| 1821 | X | | X | | X | X |
| 1818 | | X | X | | X | |
| 1811 | | | | | X | X |
| 1806 | | X | X | | X | |
| 1798 | | X | X | | X | X |
| 1795 | X | | X | | | X |
| 1790 | | | | | X | X |
| 1786 | | | X | | | |
| 1783 | | X | | | X | X |
| 1780 | | X | | | | |
| 1776 | X | X | | | X | X |
| 1771 | | | | | X | X |
| 1758 | X | | | | | X |
| 1752 | X | | | | X | X |
| 1744 | X | | X | | | X |
| 1734 | | | X | | | |
| 1729 | | | | | | X |
| 1719 | | | X | | | |
| 1713 | | | | | | X |
| 1707 | | | X | | | |
| 1702(?) | | | | | | X(?) |
| 1693 | | | | | | X |
| 1681 | | | | | | X |
| 1672 | X | | | | | |
| 1657 | | | | | | X |
| 1651 | | | | | | X |
| 1646 | | | | | | X |
| 1642 | | | | | | X |
| 1618 | | | | | | X |
| 1598 | | | | | | X |
| 1586 | | | | | | X |
| 1552 | | | | | | X |
| 1545 | | | | | | X |
| 1444 | | | | | | X |
| pith date | 1648 | 1724 | 1617 | rotten | rotten | 1428 |

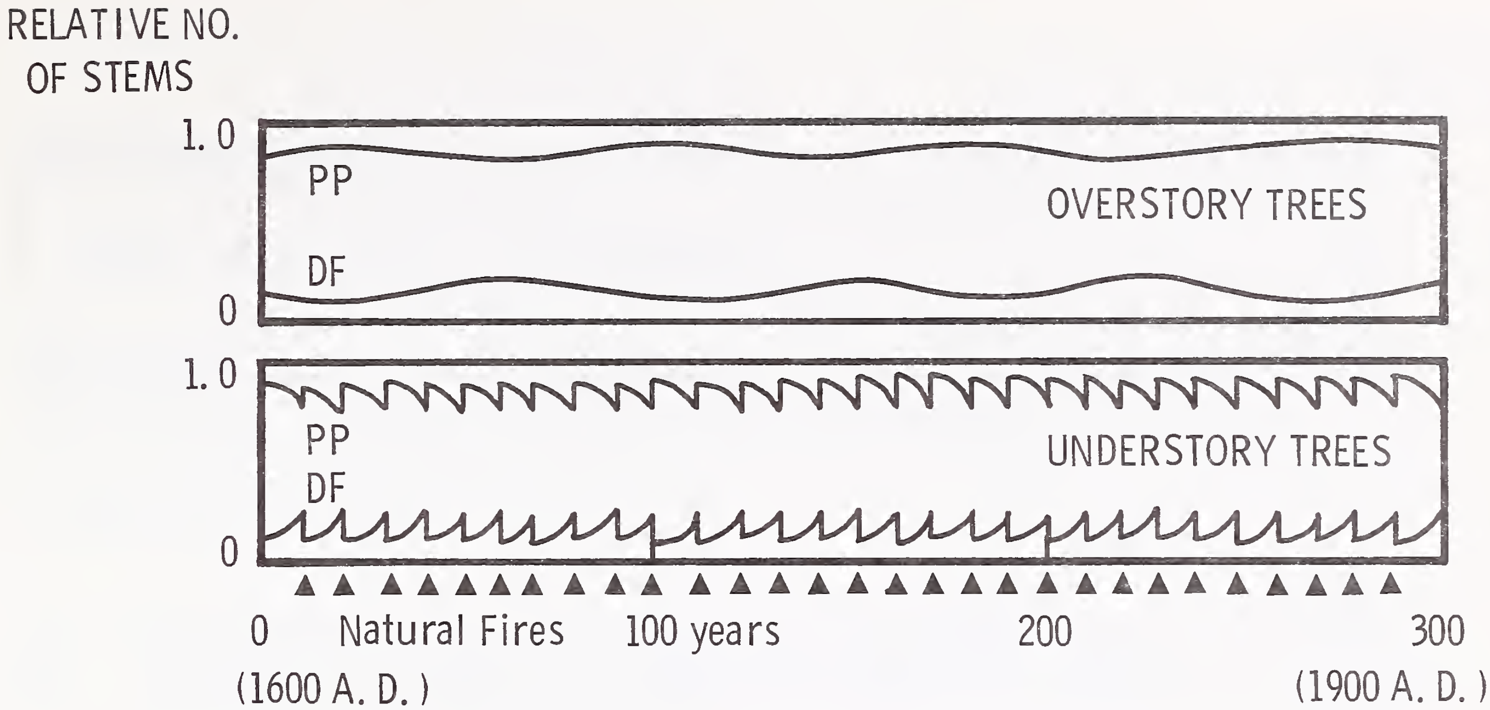



*Figure 6.—The effect of succession on relative abundance of ponderosa pine and Douglas-fir at Lick Creek: hypothesized succession with underburns at 5- to 15-year intervals.*

Although the sites at Lick Creek are capable of supporting both ponderosa pine and Douglas-fir, the pre-1900 fire regime brought about development of all-aged (or many-aged) stands of ponderosa pine. Douglas-fir saplings are readily killed by surface fires, whereas some ponderosa pine saplings often survive. (Small Douglas-firs are sensitive to fire because of their photosynthetically-active bark along with their small buds and fine branchlets. Ponderosa pines of comparable size have already developed a layer of corky outer bark and they have large, protected buds and thicker twigs.) Thus, there was a continual selection pressure against Douglas-fir. This phenomenon was acknowledged by W. W. White (1924, see footnote 1). Figure 6 depicts relative abundance of these two conifers in both the overstory and the understory during the pre-1900 fire regime. If it had not been for surface fires, the more shade-tolerant Douglas-fir would have been able to regenerate under the pine and eventually dominate the site, as shown in figure 7.

Field observations by Leiberg (1899) and historical accounts compiled by Weaver (1974) and Barrett (1980, 1981) state that many pre-1900 ponderosa pine/Douglas-fir forests had open, grassy undergrowth, and this is borne out by the 1909 photographs at Lick Creek, as well as by two 1898 photographs taken by Leiberg (1899) in similar forests a few miles north of the Lick Creek area (fig. 8).

The native, dry grassland species—bluebunch wheatgrass, Idaho fescue, and arrowleaf balsamroot (readily identifiable in the early photographs)—formed the undergrowth on the drier sites (PSME/CARU-PIPO and PSME/SYAL-CARU). The undergrowth on moist habitat types (PSME/VAGL-ARUV and PSME/VACA) was primarily sod-forming (rhizomatous) woodland grasses—pinegrass and elk sedge—along with the low shrubs—kinnikinnick, snowberry, white spiraea, dwarf huckleberry, and blue huckleberry. On both dry and moist habitat types, large shrubs like bitterbrush, willow, and serviceberry, as well as understory conifers were killed back by the frequent ground fires.

The 1909 photos, as well as the Leiberg (1899) photos, show that although the understories were open, the stands were heavily stocked with large ponderosa pines. They had clear boles because the lower limbs had been shaded out and possibly scorched by fire. Modest growth rates and relatively high basal areas of tree stems per acre attest that these early stands were fully stocked or overstocked in terms of timber production. Consequently, in addition to fire, dominance of large pines contributed to a lack of tree regeneration and shrubs in the understory. Saplings and shrubs were probably also inhibited by the well-developed overstory canopy and tree root systems utilizing much of the soil moisture and nutrients.

The overstory pines usually lived 300 to 500 years (Arno 1976). They evidently died and were replaced individually or in small groups. When openings occurred, new pines would generally grow and fill them. Some saplings would succumb to damage by the next surface fire, but others would survive. Occasionally, combinations of unusually dry years coupled with epidemics of yellow pine butterfly (*Neophasia menapia*) and mountain pine beetle (*Dendroctonus ponderosae*) may cause substantial mortality as they did in some dry sites in the Bitterroot Valley during the early 1970's. C. A. Wellner (personal communication, USDA Forest Service retiree, Moscow, Idaho) notes that the beetle caused heavy losses at Trapper Creek and in some other areas of the Bitterroot in the mid- to late 1930's, which were dry years. Still, old-growth ponderosa pine forests with open understories perpetuated by surface fires evidently dominated the Lick Creek area for centuries prior to 1900.

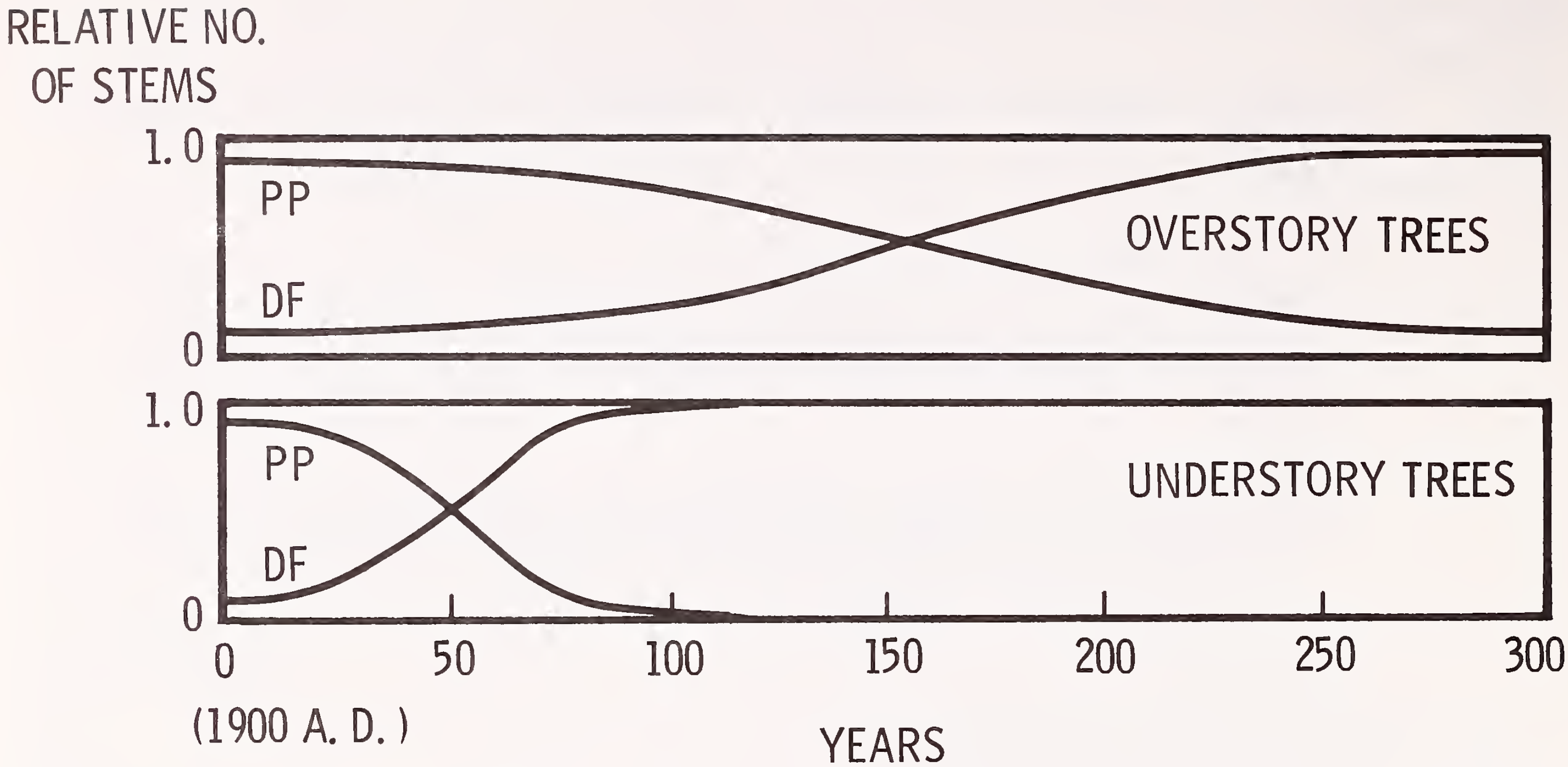



*Figure 7.—The effect of succession on relative abundance of ponderosa pine and Douglas-fir at Lick Creek: hypothesized succession with fire control and no cutting.*

*Figure 8.—Photo by J. B. Leiberg in 1898 showing heavily stocked ponderosa pine stand with open understory in the Bitterroot Valley between Kamas and Lost Horse Creeks.*

# PHOTO RECORD OF PLANT SUCCESSION AFTER TIMBER HARVESTING

Figure 9.—Photopoint 1: 1909-79.

**1909.**
Camera faces southeast toward Lick Creek scalers' cabin and clearcut on private land in distance. Ground cover is largely herbaceous species with high incidence of lupine. Scattered patches of low shrubs are also evident (PSME/SYAL-CARU h.t.). Scattered willows occupy the more moist sites below Ranger Earl Tanner. A few widely scattered young conifers are also evident. (USDA FS Photo 86467)

**1925, 16 YEARS LATER.**
Establishment and growth of conifers has resulted in a marked change in the understory. Snag at right center was a living tree in 1909. (USDA FS Photo 204817)

**1937, 28 YEARS LATER.**
Former view is now almost entirely screened by young ponderosa pine. The herbaceous understory does not appear to be as luxuriant as formerly. Willows in opening at left are considerably larger. (USDA FS Photo 354395)

**1948, 39 YEARS LATER.**
Continued growth of conifers has resulted in complete closure of understory in midground. Snowberry shrubs are evident. (USDA FS Photo 452646)

Figure 9.—Continued.

**1958, 49 YEARS LATER.**
Construction of system road has altered the soil surface in foreground. Shelterwood cut in 1952 is not apparent because of screening by young pine. (USDA FS Photo 487741)

**1968, 59 YEARS LATER.**
A selection cut in 1962 and precommercial thinning in 1966 have opened the stand and allowed appreciable growth. Willows can be seen below road. (USDA FS Photo 518769)

**1979, 70 YEARS LATER.**
View is once again screened by growth of young pines in foreground that became established on scarified soil following logging. A stand of bitterbrush not pictured behind camera point also regenerated as a result of disturbance. (USDA FS Photo)

Figure 10.—Photopoint 2: 1909-79.

**1909.**
Looking southwest across open ponderosa pine dominated slopes from a point 75 yards above fig. 9 (dry extreme of the PSME/CARU-PIPO h.t.). Original stand appears to have been quite open before logging. A deeply incised skid trail is evident in midground. A few widely scattered young conifers and willows are growing on slopes below. Recent analysis of stump at feet of Ranger Tanner shows evidence of 5 different wildfires prior to logging. (USDA FS Photo 86475)

**1927, 18 YEARS LATER.**
Pine regeneration screen view, while some mature trees have fallen to ground. An unidentified shrub now occupies site at right corner of photo. (USDA FS Photo 221277)

**1937, 28 YEARS LATER.**
View is completely screened by heavily overstocked young pines. Pine at right center has died. Suppressed shrub at right corner of photo persists beneath canopy of young pines. (USDA FS Photo 354396)

**1948, 39 YEARS LATER.**
Heavy stocking of young pine appears to have stagnated. Note fire mosaic on far slope that apparently occurred in 1875. Pine at left center has died. (USDA FS Photo 452645)

Figure 10.—Continued.

**1958, 49 YEARS LATER.**
A shelterwood cut in 1952 removed tree at right and snag is also gone. Young pines have grown modestly despite heavy overstocking, while buildup of ground fuels is evident. (USDA FS Photo 487742)

**1968, 59 YEARS LATER.**
Wyman Schmidt views selection cut in 1962 that removed the mature pine that had been present in left corner of photo since 1909. Precommercial thinning in 1966 has opened up foreground. Ground fuels have increased by addition of slash. Thinning has allowed leave trees to put on good growth. (USDA FS Photo 518776)

**1979, 70 YEARS LATER.**
Thinning of the young pine stand has resulted in establishment of bitterbrush in left foreground and to right of old stump. Willows are also evident in foreground. Growth of young pines is accelerating. (USDA FS Photo)

Figure 11.—Photopoint 3: 1909-79.

**1909.**
A northwesterly view of cleanup operation following cutting in an open-grown ponderosa pine (PSME/CARU-PIPO h.t.). Although slash piles obstruct clear view, the understory apparently lacks shrubs. Perennial grasses and forbs predominate. (USDA FS Photo 86466)

**1927, 18 YEARS LATER.**
Young Douglas-fir and ponderosa pine have become established in the background. A few young pine are also scattered through foreground. Willows 4-6 feet in height now occupy site at right midground of photo. Others of smaller growth form are also evident. Kinnikinnick predominates at base of tree at right foreground. Litter is beginning to accumulate. (USDA FS Photo 221278)

**1937, 28 YEARS LATER.**
Ponderosa pine and Douglas-fir regeneration continues to close the understory in background. Growing conditions for young trees and willow have been enhanced by mortality and windthrown standing timber. Note growth of willow in right midground. Litter continues to accumulate. (USDA FS Photo 344401)

**1948, 39 YEARS LATER.**
Growth of understory now obstructs view of background. Willow at right midground is obscured by young pines. (USDA FS Photo 452643)

Figure 11.—Continued

**1958, 49 YEARS LATER.**
A shelterwood cut was made in this general area in 1952, but its influence is not evident. Continued growth of young conifers has resulted in a thicker understory. The large willows at right are becoming senescent. Litter buildup is heavy. Debris may be the result of 1952 logging outside view of photo. Kinnikinnick continues to predominate at base of tree at right. (USDA FS Photo 487746)

**1968, 59 YEARS LATER.**
A selection cut in 1962 and precommercial thinning in 1966 opened up the area considerably. Note decomposition of larger materials. Large willows at right contain many dead branches, but removal of young conifer competition has provided improved growing conditions. A bitterbrush shrub has become established near tree in right foreground. (USDA FS Photo 518768)

**1979, 70 YEARS LATER.**
Overstory canopy is more closed as a result of tree growth. Willows at right show some new growth. New willows are evident in foreground, while the one in front of tree at left which became established between 1909 and 1927 is slightly larger than in former years. Note the increased size of the bitterbrush plant. (USDA FS Photo)

Figure 12.—Photopoint 4: 1909-79.

**1909.**
Looking northeast through a more heavily stocked ponderosa pine stand at a point about one-half mile northeast of fig. 11. The ground cover around C. H. Gregory (in distance) and W. W. White is predominantly herbaceous species with a high incidence of balsamroot (PSME/CARU-PIPO h.t.). The dark low-growing shrubs around White appear to be snowberry. Large willows are evident on left edge of photo and in front of White. (USDA FS Photo 86469)

**1927, 18 YEARS LATER.**
The two willows in 1909 scene have grown considerably and now contain many dead branches. Other willows have become established in midground, while young ponderosa pine can be seen in localized areas. The herbaceous ground cover persists. Taken later in the season, this view pictures balsamroot at a cured stage of growth. Note fire-scarred stump on right. (USDA FS Photo 221280)

**1938, 29 YEARS LATER.**
Young pine growth is beginning to occupy localized sites in understory. A tree on right has blown down, and the willow in foreground that was present in 1909 has become senescent. In foreground, the low shrub component is less evident, but this may be a seasonal difference. (USDA FS Photo 354400)

**1948, 39 YEARS LATER.**
Two mature pines have fallen to ground. Growth of young pines are closing in portions of understory. Young pine at right foreground is screening senescent willow. Herbaceous plants and snowberry in foreground have put on good growth. (USDA FS Photo 452641)

Figure 12.—Continued

**1958, 49 YEARS LATER.**
A shelterwood cut in 1952 removed several of the merchantable trees and left slash on the ground. Plants occupying sites near left edge of photo appear to be bitterbrush. (USDA FS Photo 487747)

**1968, 59 YEARS LATER.**
A 1962 selection cut and 1966 percommercial thinning have resulted in a more open landscape with increasing slash on the ground. The bitterbrush plants are more evident, while willows in the midground have been favorably influenced by removal of young conifers. (USDA FS Photo 518770)

**1979, 70 YEARS LATER.**
Rapid establishment and growth of new conifers has screened the open view of 1968. Growing conditions for bitterbrush and willow have deteriorated because of competition from conifers for sunlight and moisture. Partial cutting and thinning in 1952, 1955, 1962, and 1966 have allowed more conifer regeneration than the early, light 1906-09 cut. (USDA FS Photo)

Figure 13.—Photopoint 5: 1909-79.

**1909.**
The camera faces south-southeast into the Lick Creek drainage. Camera point for fig. 14 is below and to the left. E. C. Clifford examines partial cut which opened up ponderosa pine stand (PSME/CARU-PIPO h.t.). (Note clearcut in distance pictured in fig. 14.) Understory is predominantly perennial grasses with high incidence of balsamroot. A low-growing willow can be seen at left foreground, while other widely scattered willows are evident in background. (USDA FS Photo 86473)

**1927, 18 YEARS LATER.**
Ponderosa pine regeneration is profuse in midground. Willow in foreground has grown considerably as has another on left edge of photo behind tree. Down trees and broken-top pines (center and right) evidently resulted from wind damage after stand was opened. (USDA FS Photo 221281)

**1938, 29 YEARS LATER.**
Young ponderosa pine growth continues, at a modest rate. Although willow at left has not leafed out, it appears to contain dead branches. Gradual loss of overstory trees continues. (USDA FS Photo 361707)

**1948, 39 YEARS LATER.**
Understory is now dominated by young ponderosa pine. The pine in center foreground that was apparently dead in 1938 has lost its bark, while the two trees to the right have toppled. Opening of the overstory may have improved growing conditions for herbaceous plants. (USDA FS Photo 452650)

Figure 13.—Continued

**1958, 49 YEARS LATER.**
Photo was taken too far to the left, but it does show that young ponderosa pine have grown well, considering that they are heavily overstocked. The increased canopy in foreground appears to be restricting growth of herbaceous plants. (USDA FS Photo 487743)

**1968, 59 YEARS LATER.**
Construction of road in 1967 and overstory removal in 1968 resulted in considerable site modification. The willow in foreground of 1909 scene in front of William Chord had persisted despite heavy pine competition and is now of large growth form with little foliage near the ground. Mullein in foreground seeded in on disturbed soil. (USDA FS Photo 518774)

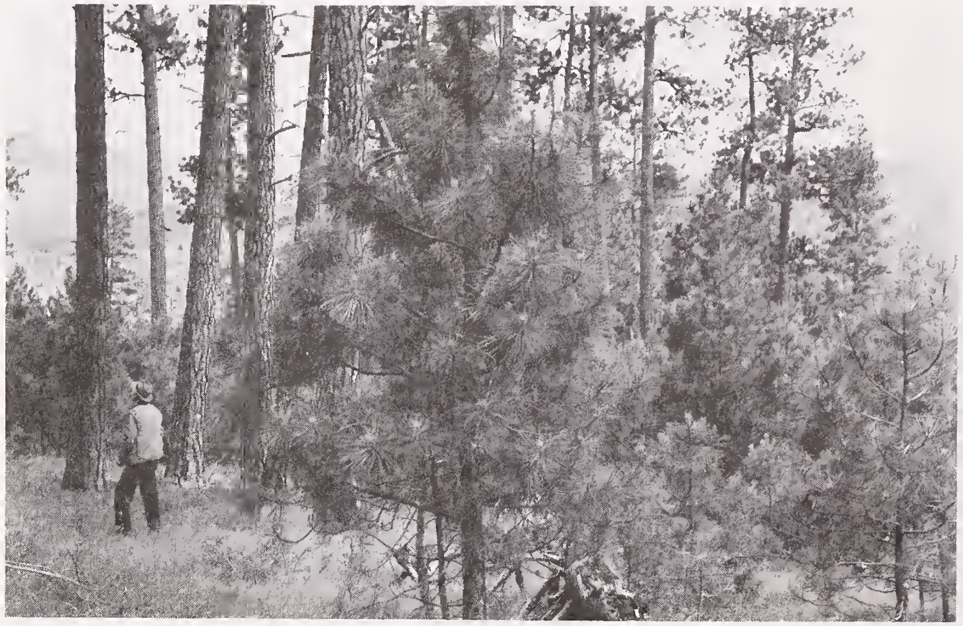
**1979, 70 YEARS LATER.**
Opening of stand in 1968 allowed good growth on pines and release and establishment of willow. The large willow in foreground shows new growth near ground level from suckering. Spotted knapweed dominates disturbed site in foreground. Far slope that was clearcut in 1909 is now covered by pole-size conifers. (USDA FS Photo)

Figure 14.—Photopoint 6: 1909-79.

**1909.**
The camera faces southeast in a ponderosa pine stand (PSME/CARU-PIPO h.t.) that has been selectively logged. W. W. White assesses the work. Understory vegetation is largely comprised of herbaceous species with balsamroot evident. Low shrubs in immediate foreground cannot be identified. Note clearcut on private land in distance. (USDA FS Photo 86471)

**1925, 16 YEARS LATER.**
Ponderosa pine seedlings have become established, while willow is evident, particularly in area formerly covered by slash pile at right. Blowdown has occurred in foreground while distant slopes (in the clearcut) support scattered tall shrubs and conifer regeneration. (USDA FS Photo 204818)

**1938, 29 YEARS LATER.**
The open parklike appearance of the understory has been replaced by dense patches of young ponderosa pine. Willows have grown appreciably, but are not yet leafed out in this April scene. Blowdown of an occasional overstory pine is resulting in reduced crown cover. (USDA FS Photo 361708)



**1948, 39 YEARS LATER.**
Growth of young ponderosa pine masks much of former view. Ground cover around Kenneth Boe is largely herbaceous species. Clearcut in distance now supports a developing conifer stand. Willows are suppressed. (USDA FS Photo 452648)

Figure 14.—Continued

**1958, 49 YEARS LATER.**
The camera has swung too far to the left. Increased development of pine understory has created ladder fuels. Shading and litter accumulation apparently has inhibited herbaceous growth. (USDA FS Photo 487744)

**1968, 59 YEARS LATER.**
Overstory removal in 1968 resulted in a landscape that is dominated by young ponderosa pine. Foreground has been heavily scarified by tractor skidding. After 59 years, willow on edge of stand at left center of photo contains much dead material. (USDA FS Photo 518772)

**1979, 70 YEARS LATER.**
Ponderosa pine growth response to overstory removal has been very good despite poor condition of some trees in 1968. Scarified soil in foreground allowed establishment of pine seedlings, bitterbrush, willow, pinegrass, and knapweed. (USDA FS Photo)

Figure 15.—Photopoint 7: 1909-79.

**1909.**
Looking north across part of 1906 clearcut on private land. Photopoints 5 and 6 are in conifers at right in distance. Foreground supported ponderosa pine and a higher complement of Douglas-fir than on other sites in this photo series (PSME/VAGL h.t.). Residual conifers below are mostly Douglas-fir. Scattered patches of aspen and willow have been released following logging. Slopes below support luxuriant ground cover of pinegrass and low shrubs. A network of haul roads and skid trails are visible. (USDA FS Photo 86479)

**1925, 16 YEARS LATER.**
Conifer regeneration has developed more rapidly on north slope and valley bottom than on the distant south slope. Douglas-firs are mostly represented. Aspen and willow have grown profusely. Note large willow in foreground. (USDA FS Photo 204830)

**1938, 29 YEARS LATER.**
Conifers now dominate slope below and valley bottom. Ponderosa pines that were not visible in 1925 are now apparent in immediate foreground. Most of south-facing slope in view now supports vigorous young forest except for a few openings, especially on convex slopes. Large willow in foreground has not leafed out. (USDA FS Photo 361705)

**1948, 39 YEARS LATER.**
The original scene is now almost completely screened by vigorous young conifers. Willows in foreground are still in a healthy condition. (USDA FS Photo 452638)

Figure 15.—Continued

**1958, 49 YEARS LATER.**
Conifers show further height and diameter growth, whereas willow is declining. (USDA FS Photo 487749)

**1968, 59 YEARS LATER.**
Precommercial thinning was carried out in 1968, but photo indicates insignificant removal on this site. Willows in foreground are leafed out and therefore more evident. (USDA FS Photo 518778)

**1979, 70 YEARS LATER.**
Canopy appears less dense than in 1968. (USDA FS Photo)

Figure 16.—Photopoint 8: 1909-79.

**1909.**
Looking east-southeast at a selection cut in primarily ponderosa pine (PSME/VACA h.t.). Pole-size Douglas-fir can be seen at right. Ground cover is herbaceous species with low shrubs and scattered small willows and snowberry. A large willow is growing in foreground on left. Charred log at the foot of W. W. White (center), and snag at left center of photo attest to past wildfire. Clifford, the first planting specialist in the Northern Region, is seated on a charred log. (USDA FS Photo 86470)

**1927, 18 YEARS LATER.**
Willows are now a conspicuous part of the understory in midground, while foreground has taken on a more grassy appearance. Douglas-fir and ponderosa pine regeneration are contributing to a much more developed understory than before. (USDA FS Photo 221285)

**1937, 28 YEARS LATER.**
Young conifers are beginning to dominate the understory; willow has grown appreciably in midground. Litter accumulation is evident in foreground, while the tree canopy on skyline is less dense because of mortality and windthrow. (USDA FS Photo 354397)

**1948, 39 YEARS LATER.**
Willows are beginning to die back. Competition from young conifers is becoming intense. Litter accumulation in foreground includes a high incidence of pine cones. (USDA FS Photo 452649)

Figure 16.—Continued

**1958, 49 YEARS LATER.**
The open understory of 1909 has been replaced by a dense growth of young conifers. Willows are not leafed out, but nonetheless contain many dead branches. Although grasses persist in foreground, their growth seems to be inhibited because of accumulative litter. (USDA FS Photo 487748)

**1968, 59 YEARS LATER.**
Precommercial thinning and pruning were carried out in 1968. The removal of trees in foreground, dozer scarification, and deposition of material from road construction resulted in establishment of mullein, thistle, and many ponderosa pine seedlings. Young willows can be seen at left center of photo. (USDA FS Photo 518771)

**1979, 70 YEARS LATER.**
Photo documents how ponderosa pine can successfully regenerate on a disturbed (scarified) site. The ground cover in immediate vicinity is largely knapweed, dogbane, and Canadian thistle, which are disturbance indicators. (USDA FS Photo)

Figure 17.—Photopoint 9: 1909-79.

**1909.**
A northwest view back toward previous camera points. Ground cover is comprised of herbaceous species including balsamroot and low-growing snowberry and spirea (PSME/SYAL-CARU h.t.). Young Douglas-fir can be seen in understory. (USDA FS Photo 36478)

**1927, 18 YEARS LATER.**
Willow are now predominant in opening at left in midground and are also evident in foreground. A few bitterbrush plants are also present in foreground. Douglas-fir regeneration is well established. (USDA FS Photo 221284)

**1938, 29 YEARS LATER.**
Douglas-fir growth is competing with willow and bitterbrush. Both shrubs have grown considerably, but dead branches are particularly evident within canopy of several willows. Note amount of dead material in willow at right edge of photo. (USDA FS Photo 361701)

**1948, 39 YEARS LATER.**
Young Douglas-fir stand has overtopped much of the shrub complement. A few bitterbrush and willow plants persist in openings, while snowberry is growing vigorously. (USDA FS Photo 456326)

Figure 17.—Continued

**1958, 49 YEARS LATER.**
Early skyline view has been completely screened by growth of conifers. Closure of understory has resulted in further deterioration of large shrubs. Note dead willow at left center of photo. (USDA FS Photo 487739)

**1968, 59 YEARS LATER.**
Precommercial thinning in the 1960's resulted in improved conditions for willow, bitterbrush, and other understory plants. Slash has increased ground fuels. (USDA FS Photo 518777)

**1979, 70 YEARS LATER.**
Growth of Douglas-fir screens view. These ladder fuels are beginning to create a hazard to second growth timber and the few trees left from the original stand. (USDA FS Photo)

Figure 18.—Photopoint 10: 1909-79.

**1909.**
Facing nearly due west from ridge northeast of Como Lake. Light selection cut in open ponderosa pine. Ground cover is comprised of perennial grasses and forbs, including balsamroot (PSME/CARU-PIPO h.t.). A few low-growing bitterbrush plants can be seen in the vicinity of horses and in distance on left. A group of willows can also be seen behind horseman at left center. (USDA FS Photo 87357)

**1925, 16 YEARS LATER.**
Bitterbrush plants on left and willow in distance, more evident in this winter scene, have increased in size. Young conifers are beginning to fill in the understory in background. (USDA FS Photo 204815)

**1938, 29 YEARS LATER.**
Several pines in foreground have been cut, some have died, and others have fallen to the ground. Ponderosa pine and Douglas-fir regeneration is profuse, while the willow in distance is larger. Bitterbrush has increased, but regeneration appears minimal. Slash and windfall have resulted in an increase in heavy fuels. Mullein can be seen in left foreground for the first time. (USDA FS Photo 361704)

**1948, 39 YEARS LATER.**
Former open view is screened by growth of young conifers. Bitterbrush plants have continued to grow, but are beginning to receive competition from conifers for space. Willow in distance has been overtopped by conifers. Dead trees have toppled, adding to fuel load. Slash in foreground has decomposed somewhat, while balsamroot is not evident and mullein has increased in occurrence. (USDA FS Photo 452639)

Figure 18.—Continued

**1958, 49 YEARS LATER.**
Growth of young ponderosa pine and Douglas-fir dominate skyline, thereby obscuring view of the few remaining mature ponderosa pine in distance. Competition by young pines in foreground has apparently caused several of the bitterbrush plants to deteriorate. Heavy ground fuels show considerable decomposition. (USDA FS Photo 487738)

**1979, 70 YEARS LATER.**
Understory is dominated by increased pine growth that is shading out bitterbrush. Past disturbance has allowed knapweed to predominate in foreground. (USDA FS Photo)

**1968, 59 YEARS LATER.**
Precommercial thinning and pruning in 1968 removed mature pines and opened up young pine stand. This benefited some bitterbrush plants (reference to other photo sequences), but those in left foreground under and near leave trees show further deterioration. Slash has added to heavy fuels, while down material is more decomposed. (USDA FS Photo 518767)

Figure 19.—Photopoint 11: 1909-1948.

**1909.**
View is south-southeast through an open ponderosa pine stand selectively cut in 1907 or 1908 (PSME/SYAL h.t.). Luxuriant grass/forb cover reflects prelogging conditions. Note fire-scarred ponderosa pine and lone Douglas-fir seedling immediately to the left of W. W. White. A low-growing bitterbrush plant can also be seen between White and stump. (USDA FS Photo 86480)

**1927, 18 YEARS LATER.**
Douglas-fir regeneration has resulted in marked change in understory. Grass/forb ground cover persists, but now bitterbrush and snowberry are more evident in foreground. Pine stand is somewhat less dense because of cutting or windfall. (USDA FS Photo 221282)

**1938, 29 YEARS LATER.**
Douglas-fir understory continues to increase in size and density. Some overstory trees continue to die. (USDA FS Photo 361703)

**1948, 39 YEARS LATER.**
Original view is now screened out by growth of young Douglas-fir. Ground cover in foreground now has considerable numbers of low shrubs. Snowberry appears to predominate. (USDA FS Photo 452640) (Entire 70-year sequence not replicated.)

## INTERPRETATIONS OF VEGETATIVE CHANGE

The 1907-11 logging operations and subsequent lack of ground fires dramatically changed the patterns of plant succession at Lick Creek. Large quantities of overstory pines were felled, creating sizable openings. Logs were skidded and slash was burned in piles, locally (over a small percentage of the ground) scraping off or consuming surface vegetation, pine needle litter, and humus, and exposing mineral soil. The photo sequences covering the next 40 years show these results: Tall shrubs (especially Scouler willow) and tree regeneration became established in direct proportion to the amount of stand opening and ground disturbance. The response of tall shrubs and tree regeneration was most vigorous on the moist habitat types.

Even though overstory Douglas-firs were mostly removed in the 1907-11 logging, Douglas-fir regeneration increased markedly thereafter. This regeneration is a result of: (1) the absence of surface fires, and (2) the opening up of the stand through logging. Figure 20 depicts the probable tree succession associated with fire control and partial cutting in this forest type. Note that this shows a speedup in natural succession, as illustrated in figure 7. Douglas-fir regeneration increased markedly on the moist habitat types and under lighter cutting treatments. Pine regeneration was more successful in the dry habitat types and with greater stand opening and site disturbance.

At some photopoints several of the large pines left after early logging died from windthrow and mountain pine beetle attacks. This provided further opportunity for understory trees and shrubs to develop. Also, the photo sequences allow observation of the slow progression of death, decay, and downfall including disintegration of stumps.

On dry habitat types, the original dry grassland type of undergrowth was replaced within a few decades by conifers and shrubs, including antelope bitterbrush. Often, dense pole stands developed after 30 to 40 years, tall shrubs began to be shaded out, and undergrowth, in general, became sparse. After thinning of the poles and removal of the remaining large pines in the 1950's and 1960's, the tall shrubs and other undergrowth became more dense. Today, after thinning, the remaining pole-size conifers generally show good vigor. Composition has shifted toward mixed stands of ponderosa pine and Douglas-fir, and with continued partial cuttings and lack of surface fires, Douglas-fir will probably dominate on many sites.

In general, the photos show that the dry habitat types have changed from original dominance by large ponderosa pine with bunchgrasses beneath to thrifty pole-size pine and Douglas-fir with scattered willow and undergrowth of sylvan species like pinegrass, elk sedge, and snowberry. Bitterbrush occupies localized dry sites that were heavily scarified.

The transition shown on the moist habitat types begins with stands dominated by large ponderosa pines and with some Douglas-fir. These had open understories and ground cover composed of low shrubs and pinegrass. After the 1907-11 logging and subsequent fire suppression, vigorous pole/tall shrub communities of Douglas-fir, ponderosa pine, and Scouler willow developed, with a low shrub and pinegrass ground cover beneath. Mechanical thinning of the poles since 1950 has kept the willow from becoming badly suppressed.

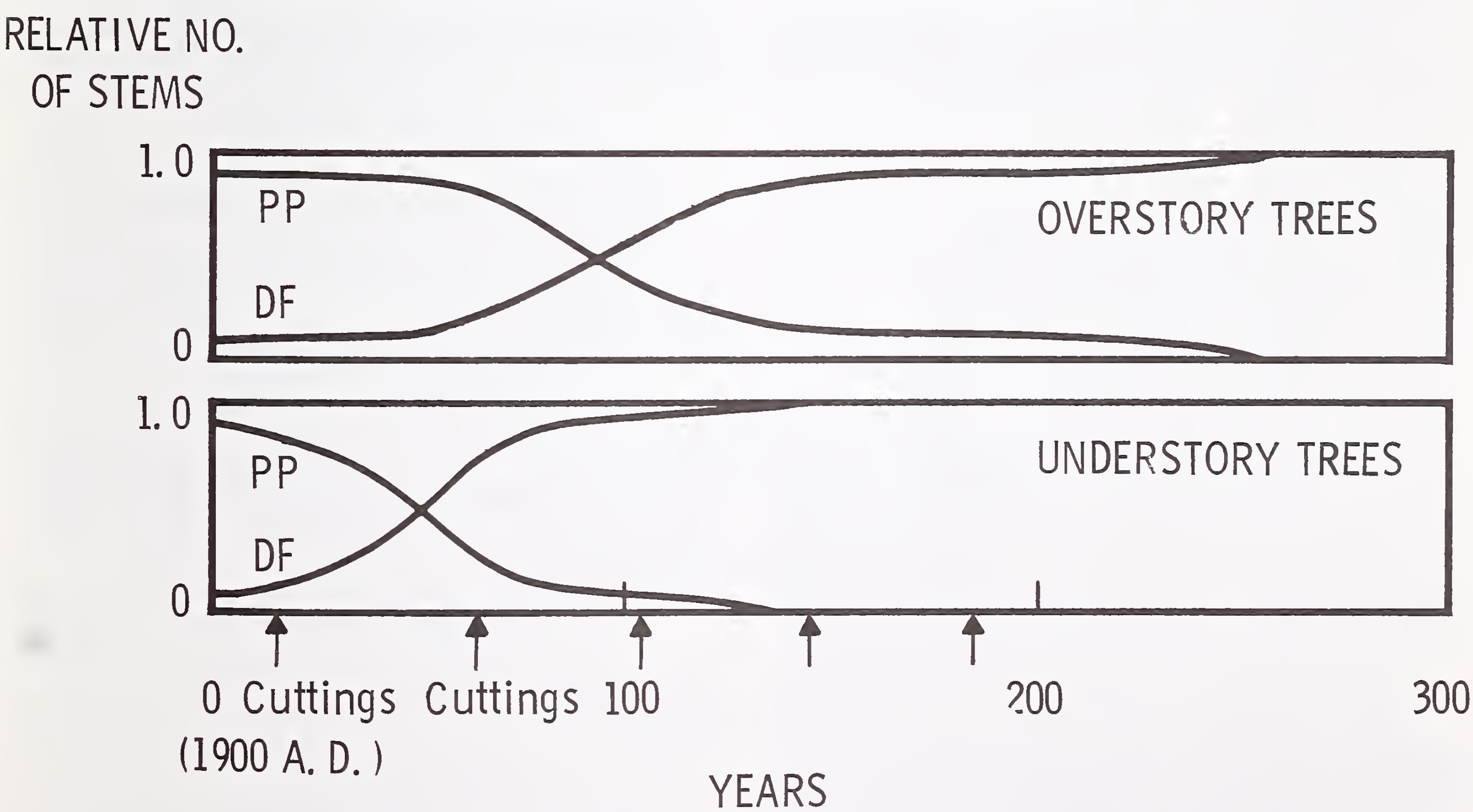



*Figure 20.—The effect of succession on relative abundance of ponderosa oine and Douglas-fir at Lick Creek: hypothesized succession with fire control and partial cuttings.*

## FUELS CHANGE

Logging and the exclusion of wildfire resulted in a significant increase in downed woody material and in live fuels in Lick Creek. William C. Fischer, fuels specialist at the Northern Forest Fire Laboratory in Missoula, Mont., evaluated the condition of fuels by referring to his "Photo Guide for Appraising Natural Fuels in Montana Forests" (Fischer 1981). This evaluation showed that changes have been variable at photopoints 1 through 11 (figs. 9 through 19), as shown in the following tabulation:

| | Hazard rating | |
|---|---|---|
| **Photopoint** | **1909** | **1979** |
| 1, 2, 7, 9 | low | high |
| 8 | low | medium-high |
| 5, 6, 11 | low | medium |
| 3, 4, 10 | low | low |

The greatest increase in downed woody material has occurred in localized areas where heavy accumulations of untreated thinning slash were left following entries in the 1950's and 1960's. Deterioration of this slash has resulted in reduced hazard at three camera points (figs. 11, 13, and 18), but the increase in slash and live fuels over 1909 conditions has resulted in a high potential for cambial kill of small trees.

The major fuels change was the development of live ladder fuels, which increased the susceptibility of the original stand to crown fire. The potential for crown fire was highest in the early 1950's prior to logging and thinning. Overstory removal and thinning in the 1950's and 1960's reduced the potential of crowning in some localities, but establishment of ladder fuels in recent years is again increasing this potential. Because of fuel discontinuity, the likelihood of a crown fire occurring, given average burning conditions, is not great. However, a fire driven by high winds and burning under extremely dry conditions could crown and destroy second-growth timber being managed for future harvest.

The photo record strongly suggests that, prior to 1909, light loading of downed woody material and lack of ladder fuels precluded the development of crown fires. Partial cutting and fire exclusion in the ponderosa pine type results in increased downed woody material and ladder fuels. If future crown fires are to be averted, logging slash should be treated and ladder fuels thinned periodically. The judicious use of underburning at appropriate intervals (e.g., 25 to 30 years) has the potential for reducing both ground and ladder fuels as well as achieving benefits for wildlife and recreation.

Figure 21 shows hypothesized stand composition in such forests under a program of partial cuts and prescribed underburns intended to favor regeneration of ponderosa pine. The underburns would reduce fuel hazards and expose mineral soil to allow for tree regeneration. The underburns would differentially kill more of the understory Douglas-fir than pine, and the silvicultural approach would mimic the pre-1900 ecosystem processes (fig. 6).

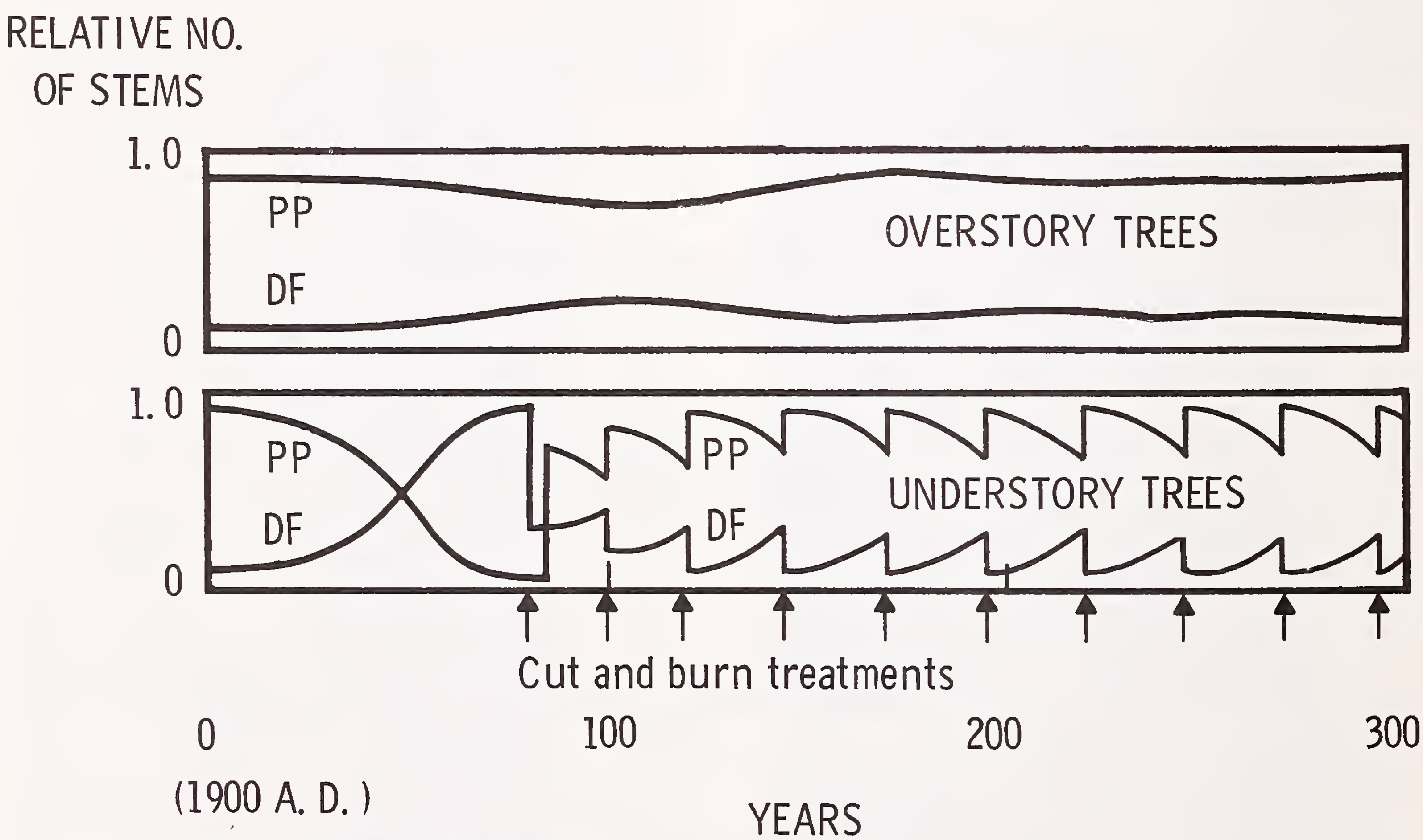



*Figure 21.—The effect of succession on the relative abundance of ponderosa pine and Douglas-fir at Lick Creek: a hypothetical selection system and prescribed underburning to favor ponderosa pine.*

## MANAGEMENT IMPLICATIONS

### Timber

Long-term interpretations of timber management in the Lick Creek area, which is fairly typical of the ponderosa pine/Douglas-fir type in western Montana, are based on (1) changes observed in repeat photos over a long period of time, (2) timber stand data collected 40 years after the initial cuttings, and (3) short-term data from limited follow-up studies. The key to the interpretation lies in the long-term observations made possible with the photos.

Ideally, a full range of even-aged and uneven-aged systems would have been established, including clear-cutting, shelterwood, seed tree, single tree selection, and group selection. Although this was not the case, some of the initial partial cuttings (single tree selection) did create conditions similar to the systems mentioned and provided some management information for those systems.

Partial cutting practices on the Lick Creek area were largely successful in meeting timber management objectives. Although timber goals were not well defined in the old records, managers aimed at maintaining reasonable growth for subsequent harvests, at regenerating the site, and at maintaining ponderosa pine as a major component of the stand. Total net board-foot growth up to the time of the second round of cuttings was nothing spectacular (average of 66 bd.ft. per acre [163 bd.ft./ha] annually).

Response following the second cutting was more encouraging, with values of 150 to 235 bd.ft. per acre (370 to 580 bd.ft./ha). This reflects a younger, more vigorous stand that is better able to capitalize on the growth potential of the site. For comparison, a 200-year-old, fully-stocked stand on similar site quality should produce about 200 bd.ft. per acre (494 bd.ft./ha) according to Meyer (1938). Considering age, vigor, and postharvest stocking of the original old-growth stand, growth appears reasonable. This forest was beyond the age when the most significant growth response could be expected.

Ingrowth into commercial sizes contributed only a minor part of the total volume growth following the original cutting. Past fires had largely excluded younger stand components. Thus, there were only a few young trees capable of capitalizing on the growing space provided by the harvest cuttings. However, younger stands now coming into their own can be expected to produce at higher cubic-volume rates than their over-mature predecessors. Board-foot values become less meaningful (because this measure applies to commercial size material) than cubic-foot as stands are converted to younger age and size classes.

Partial cuttings successfully reduced anticipated tree mortality at Lick Creek by harvesting high-risk trees. This follows the same pattern noted by Johnson (1972) in his evaluations of the western pine beetle (*Dentroctonus brevicomis*) and mountain pine beetle (*Dendroctonus ponderosae*) in nearby areas of the Bitterroot. Without the partial cuts, natural mortality would likely have been substantial in these old-growth forests. As the area is converted to younger and more vigorous stands, however, even less natural mortality can be expected.

Ponderosa pine regenerated within the first 10 years after harvesting when the canopy was opened and mineral soil had been exposed by logging. As a general rule, the more drastic the treatment, the more it favored ponderosa pine regeneration. Cone crop size, timing, and seed distribution were apparently important factors influencing regeneration on the disturbed sites. In fact, logging damage and release of the seed-bearing trees may have stimulated additional seed production. Later studies indicated that at least some ponderosa pine, particularly the younger trees, respond to these stimuli.

Frequent ground fires in the past had kept the more fire-susceptible Douglas-fir as a minor stand component. As a result, Douglas-fir seed was likely minimal after the first cutting. Douglas-fir can regenerate on much the same site, stand, and seedbed conditions as ponderosa pine, but is much more tolerant of shade and has less stringent seedbed requirements than ponderosa pine. Thus, silvicultural practices that leave heavy overstories with little or no seedbed preparation discriminate against ponderosa pine and provide Douglas-fir a distinct advantage. The virgin stand conditions where fire played a major role provided an exaggerated advantage to ponderosa pine that no longer exists under intense fire control. Under light partial cuttings with little or no site disturbance, Douglas-fir regeneration can be expected to occupy increasing proportions of the stand with a corresponding decrease in ponderosa pine.

In terms of total volume growth, there seems to be little advantage or disadvantage in favoring ponderosa pine over Douglas-fir. Although ponderosa pine was a higher value species than Douglas-fir, price differences between the two species are gradually diminishing. In fact, young and fast-growing ponderosa pine ("bull pine" in the timber trade) is less valuable than young Douglas-fir.

In addition to species value differences, there are also important disease and insect factors that justify regulating species composition. As noted by White (1924, see footnote 1), "Douglas-fir was badly infected with witch's broom (dwarf mistletoe *Arceuthobium douglasii* Engelm.) and seldom attained good size and form." Selective cuttings seldom remove all sources of dwarf mistletoe that infect the understory Douglas-fir. Also, advance regeneration in dwarf mistletoe-infected stands is nearly always infected prior to harvest. Thus, complete removal of the infected overstory can still leave a management problem where advance regeneration is retained following harvest cuttings. In addition, with dwarf mistletoe present in the stand, selection cuttings may actually accelerate spread of the disease. Thus, silviculture practices that shift stand composition toward Douglas-fir concurrently increase susceptibility of the stand to dwarf mistletoe.

Uneven-aged management of these forests is threatened by the western spruce budworm (*Choristoneura occidentalis*). Douglas-fir is the primary host of budworm in most of the Northern Rockies. Budworm larvae disperse particularly well in the layered stands created by uneven-aged management such as the Lick Creek partial cuttings. In fact, partial cutting methods commonly practiced for most of the first half of this century, when coupled with intense fire control, undoubtedly contributed substantially to the perpetuation of the 4 million acres of annual budworm defoliation. These practices not only produced stand structures suitable for budworm, they

also increased the proportion of tolerant tree species—the favorite hosts of budworm. Thus, most of the known ecological niches needed by budworm are adequately provided through uneven-aged management.

It appears that all of the silvicultural systems could be workable in this forest type when coordinated with stand composition, vigor, site, disease, and insect conditions. Defining the long-term objectives is the key to choice of silvicultural prescriptions. Once the management objectives are set, these observations of timber and other resources on Lick Creek provide bases for management decisions in the ponderosa pine/Douglas-fir forests of the Northern Rockies.

## Wildlife

Wildlife species have particular habitat requirements that are closely associated with vegetative type and structure. Some species such as the pileated woodpecker have specialized requirements. Others like the robin utilize a wide variety of habitats. Because of variation in habitat requirements, we can expect wildlife species to respond differently to vegetative change, depending upon the nature of the disturbance, time since disturbance, and resulting successional stage.

Fire history research and the photo record demonstrate that frequent low-intensity surface fires kept the Lick Creek understory open prior to logging in 1907-11. These light disturbances resulted in a fairly stable environment in which wildlife populations would not be expected to change significantly over time. Logging and the exclusion of wildfire have brought about marked changes in vegetation. These pronounced changes probably resulted in significant changes in populations of many wildlife species. The following interpretations are based on wildlife habitat requirements and known vegetative trends.

### SMALL MAMMALS

Wildlife species with minimal cover requirements would be favored by frequent low-intensity ground fires. Small mammal research suggests that frequent fires in earlier years insured perpetuation of openings essential to the needs of ground squirrels, pocket gophers, and deer mice (see appendix I for common and scientific names of wildlife). These species require minimal cover and tend to increase following opening of the forest canopy and an increase in herbaceous plants (Barnes 1974; Dimock 1974; Davis 1976). Closure of the forest canopy in the 1940's, 1950's, and in recent years has reduced the available habitat for these wildlife species.

Frequent ground fires would have displaced small mammals that require litter and humus for cover. Shrews are temporarily eliminated or displaced from sites where fire has removed the duff and ground vegetation and will not return until ground cover develops (Black and Hooven 1974). Voles of the genus *Microtus* are also associated with the organic layer and are temporarily eliminated by a hot ground fire (Dimock 1974). The increase in litter and humus since 1909, resulting from fire exclusion and periodic logging, has undoubtedly been favorable to these small mammals.

Golden-mantled ground squirrels and chipmunks prefer openings, but are reluctant to move very far from fallen trees, limbs, or shrub cover. Frequent ground fires may have temporarily displaced these species, but the subsequent opening of the tree canopy and increase in down woody material would favor their return (Davis 1976).

The open understory of earlier years would have been marginal habitat for cottontail rabbits and snowshoe hares. Both species are dependent on shrubs and young trees for food and protection from predators (Costa and others 1976; Grange 1965). Successional changes resulting from logging have been particularly beneficial for snowshoe hares since population highs often coincide with young pole-sized conifers (Scotter 1964; Fox 1978). Unburned slash piles in localized areas complemented cover requirements. Vegetal trends have also benefited the porcupine which prefers young conifers.

Both the red squirrel and the flying squirrel are dependent upon mature or old-growth forests that provide cone-producing trees and nesting cavities. The presettlement, low-intensity ground fires may have promoted population stability by reducing fuels and assuring perpetuation of mature conifer stands. The removal of trees by logging largely eliminated nest trees and displaced squirrels in localized areas. Development of second-growth pine stands appears to be providing sufficient cone crops for sustaining squirrel populations.

### CARNIVORES AND RAPTORS

Various carnivores and raptors, such as the longtail weasel, bobcat, coyote, sharp-shinned hawk, Cooper's hawk, and the great horned owl frequent the Lick Creek area. These predators are opportunists that respond to changes in abundance of prey. Periodic increases in prey resulting from opening the tree canopy have apparently benefited this group of wildlife species.

### BIRDS

Breeding bird populations usually respond to changes in the forest structure. Bird response by feeding habits to changes in structure was evaluated by Sidney Frissell, School of Forestry, University of Montana.

During the first decade or two after partial cutting in 1907-11, much of the Lick Creek area was in a single-story stand of varying canopy coverage. The understory and openings contained few large shrubs (figs. 9 through 14, 18 and 19). This structure type favors the following kinds of birds:

| Ground feeders | Foliage feeders |
|---|---|
| common flicker | blue grouse |
| Swainson's thrush | mountain chickadee |
| mountain bluebird | ruby-crowned kinglet |
| dark-eyed junco | warbling vireo |
| chipping sparrow | yellow-rumped warbler |
| | western tanager |
| | Cassin's finch |
| | pine siskin |
| | red crossbill |
| **Air feeders** | **Bark feeders** |
| olive-sided flycatcher | red-breasted nuthatch |
| | pygmy nuthatch |
| | pileated woodpecker |
| | hairy woodpecker |
| | yellow-bellied sapsucker |

By the third decade after initial cutting, most sites had developed into multistoried stands. Structural changes in stands probably resulted in reduced numbers of ground feeders, including the common flicker, the mountain bluebird, and the chipping sparrow. Gains could be expected in canopy feeders (solitary vireo, ruby-crowned kinglet, and evening grosbeak) and bark feeders (hairy woodpecker, brown creeper, and white-breasted nuthatch). By 1968, overstory removal caused the stand structure to more closely resemble that in 1909, except that the trees were largely thrifty poles 60 years old rather than 200 to 400 years old. Birdlife in these stands would probably be much the same as in 1909 except for localized displacement of the pileated woodpecker or other cavity nesters, and the gain of some low-canopy (shrub) feeders.

On moist sites (figs. 16 and 17), stand structure immediately following the 1907-11 logging was similar to other sites except that the tree cover was locally more dense. Bird populations were probably comparable to those on other sites. By 1927, a fairly dense but patchy understory had developed. This probably attracted some unique low-canopy (shrub) feeding species, including the rufous hummingbird, MacGillivray's warbler, and the warbling vireo. The Empidonex flycatchers would also be attracted to these sites. After 1962, logging disturbance accelerated establishment and growth of willow, thereby increasing feeding opportunities for low-canopy (shrub) feeding species. Subsequent growth of conifers and deterioration of willow was detrimental to many species on localized sites.

The clearcut on private land (fig. 15) probably resulted in a marked change in bird distribution. The foliage feeders and bark feeders would have been displaced, but the large opening was favorable for ground feeders including the common flicker, robin, Townsend's solitaire, mountain bluebird, and chipping sparrow. By 1925, the growth of aspen and willow had resulted in a desirable condition of low-canopy (shrub) feeding species. This condition was particularly desirable for ruffed grouse. The development of a single canopy forest largely displaced ground feeders. High-canopy feeders that would find this condition acceptable include the ruby-crowned kinglet, yellow-rumped warbler, and Townsend's warbler.

## BIG GAME

Historical narratives suggest that deer and elk were numerous between 1805 and 1825 in the Bitterroot Valley and vicinity (Koch 1941). Considering habitat preferences, the majority of these animals were probably white-tailed deer. Bighorn sheep and mountain goats were locally plentiful, while moose were scarce.

Big-game populations were reduced to low levels by unregulated hunting following settlement. Janson (1967) reports that in 1902 Ranger Than Wilkerson estimated "there were only seven elk left in the East Fork" of the Bitterroot River, an area that formerly supported hundreds. Low population levels led to closure of the elk season from 1913 to 1926. Deer populations at the turn of the century were also low.[2]

[2]Personal communication, Fred Hartkorn, Montana Fisheries, Wildlife and Parks Department, based on a 1950's interview with pioneer settler Bertie Lord.

An article in the September 12, 1900, edition of the Ravalli County Democrat states that deer were not plentiful and it was a "matter of general information...that no deer wintered in the woods or hills hereabouts...."

After the turn of the century, elk, mule deer, white-tailed deer, and moose populations began to increase in the upper Bitterroot Valley. Excepting white-tailed deer, population highs may have been reached in the mid-1950's. Currently, the Lick Creek area is frequented by these wild ungulates, especially during the winter and spring when forage is available only at lower elevations. The influence of habitat changes on these large mammals is not clearly understood. However, changes in habitat resulting from plant succession appear to be an important contributor to population changes.

In the Rocky Mountains, the winter diet of elk depends on forage availability. Shrubs are the primary forage on the Clearwater River in Idaho where large shrubfields predominate (Leege and Hickey 1977). Where shrubs are a minor vegetal component, grasses usually comprise much of the forage intake during the winter months (Stevens 1966). Historically, the grassy understory in Lick Creek would have been an ideal source of forage for wintering elk. Following settlement, however, it is doubtful that there was sufficient cover for elk because of the open understory and removal of trees by logging. Sparse cover subjects elk to harrassment and allows hunters to be more effective. Beall (1974) found that elk prefer dense conifer stands in which to bed. The development of young conifer stands in Lick Creek and comparable areas appears to have benefited these animals. During the past 30 years, roadbuilding in Lick Creek and other areas negated improvement in cover. Lyon (1979) has shown that elk in western Montana tend to avoid habitat adjacent to traveled forest roads. Road closures in recent years have helped reduce the impact of human disturbance.

Shrubs and trees are an essential part of the diet of mule deer, especially during the winter, when browse may comprise 75 percent or more of the food intake (Hill 1956). Browse was poorly represented in the Lick Creek area in 1909. The only appreciable source appears to have been shiny-leaf ceanothus, a fire-dependent species. Scattered remnant plants indicated this shrub was available in localized areas.

The winter carrying capacity for mule deer increased markedly after logging because of establishment and growth of willow and bitterbrush. Opening of the tree canopy increased sunlight, which stimulated production of remnant plants. Scarification of the soil surface by equipment and slash burning provided mineral soil essential for seedling establishment. Willow seedlings apparently regenerated from windborne seeds (6.5 million/lb [14.3 million/kg]) blown in from as far as several miles away. Soil scarification also favored establishment of bitterbrush seedlings, which have a low rate of survival beneath ponderosa pine where litter has accumulated (Sherman and Chilcote 1972). Seed distribution was likely facilitated by rodent caching (Sanderson 1962; West 1968).

Within the sale area, quality of mule deer habitat varies with time since logging. Browse conditions are most

favorable soon after logging. Browse deteriorates where stand densities have increased and tree canopies have closed.

White-tailed deer are indigenous to the Bitterroot Valley, but their former range appears to have been closely associated with deciduous vegetation in the valley bottom. In the past several decades, white-tailed deer have extended their range into foothills and montane forest comparable to the Lick Creek area where they are occasionally observed. Montana Fish, Wildlife, and Parks Department check station records over the past 5 years show progressive increases in annual harvests of white-tailed deer in the Bitterroot drainages (Firebaugh and others 1979). The extension of white-tailed deer range appears to parallel that noted in central and eastern Montana (Martinka 1968). The reason for this extension may be related to cover requirements. White-tailed deer are more dependent on cover than are mule deer (Keay and Peek 1980). The increased establishment and growth of young conifers in Lick Creek and other areas of the Bitterroot Valley have apparently resulted in a habitat condition suited to the needs of these animals.

At the time of settlement, moose were rarely observed in western Montana, which was reflected in the total closure on moose hunting in 1897. By the 1930's, an occasional moose was seen in Lick Creek and other Bitterroot Valley drainages. Population increases justified permit hunting in 1951.

Photographic evidence suggests that winter moose forage was marginal in the early 1900's because of poor shrub development and the sparcity of young conifers. The winter diet of moose in Montana includes a high intake of willow where this plant is a major component of the vegetation (Knowlton 1960; Dorn 1970). In forests where willow is poorly represented, willow comprises a minor portion of the winter diet (Stevens 1970). Pellet distribution and evidence of browsing in the Lick Creek area suggest that in winter moose feed heavily on willow and bitterbrush. There is also evidence that Douglas-fir is a significant source of winter forage. Stevens (1970) found that Douglas-fir was used when available and may have been a substantial part of the diet in the Gallatin Mountains of south-central Montana. The combined evidence strongly suggests that successional changes have increased moose range and numbers.

The photographic record provides evidence that changes in the forest structure have suited the habitat requirements of several wild ungulates and those small mammals and birds that require cover and a more diversified habitat than existed before settlement.

Benefits to ungulates have not been entirely the result of improved habitat conditions. More aggressive law enforcement and tighter hunting regulations also allowed populations to recover from 1900 lows caused by unregulated hunting.

Habitat suitability for wildlife inhabiting the Lick Creek area has varied with species requirements and successional stage of the vegetation. Because a majority of wildlife species are dependent upon subclimax vegetation, the best management strategy for wildlife provides for periodic renewal of subclimax vegetation. This results in a more diversified habitat that meets the needs of most wildlife species during the successional cycle.

## Domestic Livestock

Prior to establishment of the Bitterroot National Forest, livestock were turned out in the spring and allowed to scatter throughout the foothills. After establishment of the Bitterroot Forest Reserve (renamed Bitterroot National Forest in 1898), Lick Creek was included in a cattle allotment that extended from Trapper Creek on the south to Lost Horse Creek on the north, a distance of 14 miles. In 1941, the south boundary of this allotment was moved north to Bunkhouse Creek and the name changed to the Lost Horse-Bunkhouse Allotment. Currently, this allotment includes 16,076 acres, of which 4,123 acres are primary range. Domestic sheep (numbers unknown) were permitted until 1912. In 1939 (earliest record) 258 cattle were permitted. The numbers of cattle grazed have varied from a high of 364 in 1941 to a low of 93 in 1956. Because of permittee preference, there has been no grazing since 1975.

The Lost Horse Creek-Trapper C & H Allotment has been considered marginal cattle range because a large percentage is steep and covered by conifers. Use has been mostly confined to creek bottoms and adjacent openings in gentle terrain, which offer modest amounts of forage.

There is little information available on the influence of past grazing. Range observations in 1939 indicated that the allotment, other than some recently purchased private land, was in a "properly grazed condition, excepting along ridgetops which were slightly overgrazed." The Lick Creek photo series suggests that livestock use of the study area was negligible at the localities pictured and in the years the photos were taken. Plant parts are intact except for the 1927 scenes, which were made in the fall after curing. It is known that sheep use was heavy in 1912, the last year these animals were permitted to graze. The sites would not be preferred by cattle because of excessive slope, low grass production, or excessive distance from water. A 1964 Range Management Plan indicates that conifer reproduction has been satisfactory in spite of grazing.

The primary influence of livestock grazing has been the reduction of fine fuels in large openings, on ridges, and along drainages. In the past, this has reduced the potential for spread of wildfire. However, nonuse on this allotment is resulting in yearly production of fine fuels that would allow wildfire to carry through openings and across bottomlands given ignition and extreme burning conditions.

## Esthetics

The Lick Creek photo series was evaluated for esthetic qualities by Robert E. Benson, research forester, Forest Sciences Laboratory, Missoula, Mont. These photographs were compared to similar landscapes that have been extensively evaluated by viewer panels, and the panels' probable reaction was applied.

The open parklike appearance of most scenes following harvest in 1907-11 was rated high because of the uniform character of the landscape. Slash piles in some scenes, however, detracted from the view. Understory development between 1909 and 1952 resulted in a decline in scenic quality because of obstruction of views. Logging in the 1950's and 1960's provided an opportunity for more distant views, but accumulative slash detracted from the view. Scenic quality had improved by 1979 as a result of slash deterioration and screening of slash by young trees. Tree growth should improve scenic quality until stands close and views are obstructed.

Clearcutting, accompanied by fairly large amounts of scattered slash comparable to figure 15, would likely be considered obtrusive by viewers. "Thickening up" of the new timber stand following 1909 enhanced the scenic quality, but this growth became so dense that visual quality was substantially reduced.

The visual analysis suggests that the 1909 scenes were more scenic than those of later years. Tree growth between 1909 and 1952 obstructed views and resulted in reduced scenic quality. Logging improved viewing distance, but contributed to slash accumulations that the public dislikes. Deterioration of slash and screening by the growth of young conifers during recent years has improved scenic quality, but views will be impaired and scenic quality will decline as succession advances. The scenic quality of stands comparable to Lick Creek will deteriorate if stands are not kept open by logging. An acceptable level of scenic quality can be achieved by good slash cleanup, facilitated by use of prescribed fire.

## SUMMARY AND CONCLUSIONS

The Lick Creek photopoints present a rare opportunity to witness forest succession in managed ponderosa pine and Douglas-fir stands through 70 years. The photographs, accounts of early forest conditions, and fire history studies show that prior to the advent of fire suppression, lower elevation forests of the Bitterroot Valley were made up of well-stocked stands of large ponderosa pines having open understories. Surface fires swept through these stands at intervals of between 3 and 30 years, consuming most of the grass, shrubs, and tree regeneration, but causing little damage to overstory trees. The 1907-11 logging operations and subsequent lack of ground fires dramatically changed the patterns of plant succession at Lick Creek. Large quantities of overstory pines were felled, creating sizable openings. Logs were skidded and slash was burned in piles, locally scraping off or consuming surface vegetation, pine needle litter, and humus, and exposing mineral soil. The photo sequences covering the next 40 years show that tall shrubs (especially Scouler willow) and tree regeneration became established in direct proportion to the amount of stand opening and ground disturbance. The response of tall shrubs and tree regeneration was most vigorous on the moist habitat types. The transition shown on the moist habitat types begins with stands dominated by large ponderosa pines and some Douglas-fir. These had open understories, with ground cover composed primarily of low shrubs and pinegrass. After the 1907-11 logging and subsequent fire suppression, vigorous pole/tall shrub communities of Douglas-fir, ponderosa pine, and Scouler willow developed, with a low shrub and pinegrass ground cover beneath. Mechanical thinning of the pole stands since 1950 has kept the willow and undergrowth from becoming badly suppressed.

On dry habitat types, the original dry grassland type of undergrowth was replaced within a few decades by conifers and shrubs, including antelope bitterbrush. Dense pole stands developed on much of the area 30 to 40 years after logging, tall shrubs began to be shaded out, and undergrowth, in general, became sparse. After thinning of the pole stands and removal of the remaining old-growth pine in the 1950's and 1960's, however, tall shrubs and other undergrowth became more dense. Today, after thinning, the remaining pole-size conifers generally show good vigor and growth. Composition has shifted toward mixed stands of ponderosa pine and Douglas-fir. With continued light partial cuttings, Douglas-fir will probably dominate many of the sites. Cuttings that create larger openings and discriminate against Douglas-fir, and the introduction of prescribed underburns, will be needed to maintain ponderosa pine in a dominant position.

Partial cutting practices on the Lick Creek area were largely successful in meeting timber management objectives. Although timber goals were not well defined in the old records, managers aimed at maintaining reasonable growth for subsequent harvests, at regenerating the site, and at maintaining ponderosa pine as a major component of the stand. The latter goal turned out to be the most challenging. Prior to 1909, light loading of downed woody material and sparsity of ladder fuels precluded the development of crown fires. Partial cutting and fire exclusion in the ponderosa pine type resulted in increased downed woody material and ladder fuels. The major fuels change was the development of live ladder fuels, which increased the susceptibility of the original stand to crown fire. The potential for crown fire was highest in the early 1950's prior to logging and thinning. Overstory removal and thinning in the 1950's and 1960's reduced the potential of crowning in some localities, but establishment of ladder fuels in recent years is increasing this potential. If future crown fires are to be averted, logging slash should be treated and ladder fuels thinned periodically. The judicious use of underburning at appropriate intervals (25 to 30 years) has the potential of reducing both ground and ladder fuels as well as achieving benefits for wildlife and recreation

Considering past vegetative trends and current management direction, which emphasizes timber production, the best wildlife management coordination strategy is one that favors continued development of the conifer overstory while allowing regeneration and growth of shrubs and herbs. The primary tool to accomplish this objective is periodic thinning and selective logging. Underburning is desirable in localities where thinning removes the potential for crown fires. Good response from willow seedlings could be expected on sites where burning is thorough enough to expose mineral soil. Regeneration from suckers would occur where willows are well distributed and in need of rejuvenation. In some localities, where fuels are

light, an underburn would rejuvenate decadent bitterbrush. Spring or fall ignitions initiate sprouting and establishment of new plants from seed. The scenic quality of stands comparable to Lick Creek will deteriorate if stands are not kept open by logging or periodic underburning. Acceptable scenic quality can be achieved by good slash cleanup.

The massive change in forest conditions in the Lick Creek Study area has also taken place in similar habitat types in the Bitterroot Valley and western Montana. Without periodic burning or logging this forest type develops into dense tree stands, a condition detrimental to many important forest values. The combined evidence demonstrates that, carefully planned and executed, logging and burning of slash can enhance productivity and esthetic quality of the forests.

All of the silvicultural systems described in this paper would be useful in this forest type when coordinated with stand composition, vigor, and site, disease, and insect conditions. Defining the long-term objectives is the primary key to choice of silvicultural prescriptions. Once the management objectives are set, these observations of timber and other resources on Lick Creek provide a basis for management decisions in the ponderosa pine/ Douglas-fir forests of the Northern Rockies.

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# APPENDIX I
## Wildlife Species Discussed in Text

### Big Game

| | |
|---|---|
| mule deer | *Odocoileus hemionus* |
| white-tailed deer | *Odocoileus virginianus* |
| elk | *Cervus elaphus nelsonii* |
| moose | *Alces alces* |
| bighorn sheep | *Ovis canadensis* |
| mountain goat | *Oreamnos americanus* |

### Small Mammals

| | |
|---|---|
| ground squirrels | *Spermophilus* spp. |
| golden-mantled ground squirrel | *Spermophilus lateralis* |
| northern pocket gopher | *Thomomys talpoides* |
| deer mouse | *Peromyscus maniculatus* |
| voles | *Clethrionomys* spp. and *Microtus* spp. |
| shrews | *Sorex* spp. |
| chipmunks | *Eutamias* spp. |
| red squirrel | *Tamiasciurus hudsonicus* |
| northern flying squirrel | *Glaucomys sabrinus* |
| snowshoe hare | *Lepus americanus* |
| mountain cottontail | *Sylvilagus auduboni* |
| porcupine | *Erethizon dorsatum* |

### Carnivores

| | |
|---|---|
| bobcat | *Lynx rutus* |
| coyote | *Canis latrans* |
| longtail weasel | *Mustela frenata* |

### Raptors

| | |
|---|---|
| Cooper's hawk | *Accipiter cooperii* |
| sharp-shinned hawk | *Accipiter striatus* |
| great horned owl | *Bubo virginianus* |

### Birds

| | |
|---|---|
| blue grouse | *Dendragapus obscurus* |
| ruffed grouse | *Bonasa umbellus* |
| rufous hummingbird | *Selasphorus rufus* |
| common flicker | *Colaptes auratus* |
| pileated woodpecker | *Dryocopus pileatus* |
| hairy woodpecker | *Dryocopus villosus* |
| yellow-bellied sapsucker | *Sphyrapius varius* |
| olive-sided flycatcher | *Nuttallornis borealis* |
| mountain chickadee | *Parus atricapillus* |
| white-breasted nuthatch | *Sitta carolinensis* |
| red-breasted nuthatch | *Sitta canadensis* |
| pygmy nuthatch | *Sitta pygmaeae* |
| brown creeper | *Certhia familiaris* |
| Townsend's solitaire | *Myadestes townsendi* |
| robin | *Turdus migratorius* |
| Swainson's thrush | *Hylociachla ustulata* |
| mountain bluebird | *Sialia currucoides* |
| ruby-crowned kinglet | *Regulus calendula* |
| warbling vireo | *Vireo gilvus* |
| solitary vireo | *Vireo solitarius* |
| yellow-rumped warbler | *Dendrocia coronata* |
| Townsend's warbler | *Dendrocia townsendi* |
| MacGillivray's warbler | *Oporornis agilis* |
| western tanager | *Piranga ludoviciana* |
| evening grosbeak | *Hesperiphona vespertina* |
| Cassin's finch | *Carpodocus cassinii* |
| pine siskin | *Spinus pinus* |
| red crossbill | *Loxia curvirostra* |
| dark-eyed junco | *Junco hyemalis* |
| chipping sparrow | *Spizella arborea* |

# APPENDIX II
## Trees, Shrubs, and Herbs Found on Lick Creek Study Area

### Trees

| | |
|---|---|
| ponderosa pine | *Pinus ponderosa* |
| Douglas-fir | *Pseudotsuga menziesii* |
| grand fir | *Abies grandis* |
| Engelmann spruce | *Picea engelmannii* |

### Shrubs and Low Woody Plants

| | |
|---|---|
| snowberry | *Symphoricarpos albus* |
| dwarf huckleberry | *Vaccinium caespitosum* |
| blue huckleberry | *Vaccinium globulare* |
| kinnikinnick | *Arctostaphylos uva-ursi* |
| white spiraea | *Spiraea betulifolia* |
| Scouler willow | *Salix scouleriana* |
| antelope bitterbrush | *Purshia tridentata* |
| shiny-leaf ceanothus | *Ceanothus velutinus* |

### Grasses and Forbs

| | |
|---|---|
| pinegrass | *Calamagrostis rubescens* |
| elk sedge | *Carex geyeri* |
| bluebunch wheatgrass | *Agropyron spicatum* |
| Idaho fescue | *Festuca idahoensis* |
| Arrowleaf balsamroot | *Balsamorhiza sagittata* |

Gruell, George E.; Schmidt, Wyman C.; Arno, Stephen F.; Reich, William J. Seventy years of vegetal change in a managed ponderosa pine forest in western Montana—implications for resource management. Gen. Tech. Rep. INT-130. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 42 p.

Interprets changes in forest vegetation resulting from timber harvests and a marked reduction in the occurrence of fire. A series of photographs at about 10-year intervals, starting in 1909, provide the basis for describing how a ponderosa pine forest has changed since settlement. The reasons for changes and implications on wildlife, timber, fuels, esthetics, and livestock grazing are discussed.

KEYWORDS: ponderosa pine, forest succession, fire, timber, wildlife, photographic record

The Intermountain Station, headquarted in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

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